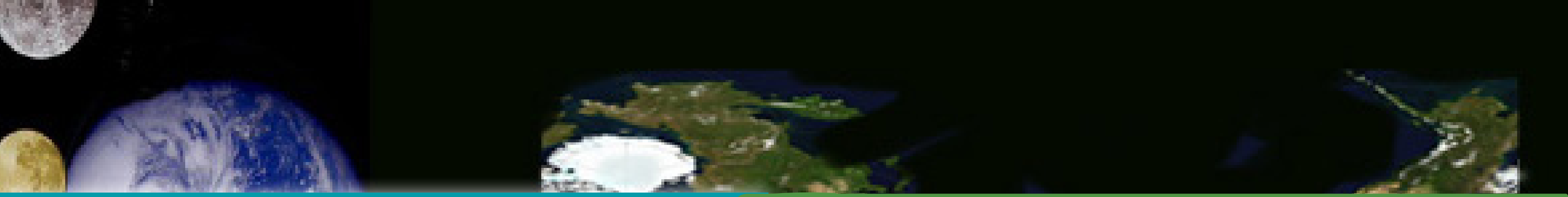

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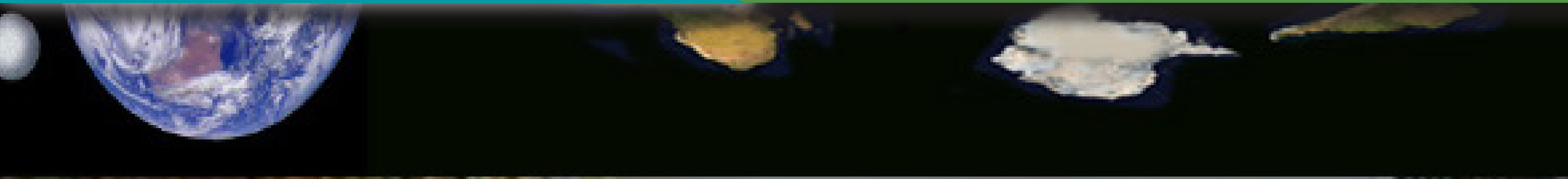

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Groundwater Exploration In Consolidated Material – Hard Rock Terrain

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Abstract

The remote sensing techniques have proved considerable importance over ground investigation methods as they provide a synoptic overview, more feasibility in data collection, less time consuming, cost effective and valuable for multidisciplinary applications. The methodology of groundwater exploration using remote sensing data is described. A list of important indicators for groundwater targeting on remote sensing images is included. The application example of satellite images for the groundwater exploration in consolidated material – hard rock terrain is discussed herein.

Key Words: Remote Sensing, Groundwater, Hard Rock Terrain.

Pages: 9 References: 18

INTRODUCTION

The groundwater is a dynamic, renewable and one of the important component of hydrologic cycle. The occurrence of groundwater at any place on the earth surface can be ascribed to a consequence of the interaction of climate, geology, hydrology, geomorphology and ecology. In Indian region, groundwater occurs in the following three types of rock formations of various geological periods:

(1) Consolidated Formations (Hard rocks) - The Indian peninsular region is almost occupied by consolidated rocks which comprise crystalline rocks e .g., granites, gneisses, schists, basalts, and compact sedimentary rocks belonging to Cuddapah and Vindhyan groups. The ground water is unevenly distributed.

(2) Semi-consolidated Formations – The semi-consolidated sedimentary rocks occur both in the peninsular and extra-peninsular regions. The sandstones of various formations constitute groundwater potential unit.

(3) Unconsolidated Formations – These formations are represented by the Quaternary sediments consisting of the Recent alluvium, older alluvium, and aeolian sands.These sediments include clays, silts, sands, gravels, pebbles, cobbles, boulders, ferruginous nodules, calcareous concretions etc. The unconsolidated sediments are favourable ground water reservoirs.

It is a well established fact that 'Remote sensing' technology provides unique information on the study and management of surface and groundwater, spatial and temporal data on precipitation, soil moisture, transpiration, evaporation, and how drainage patterns lend themselves to the development of a water range of hydrological models (Nag and Kudrat, 1998).

MATERIALS AND METHODS

Approach For Groundwater Exploration

The remote sensing data provide synoptic view, quick and valuable baseline information on the factor governing occurrence and movement of ground water such as geology, geomorphology, soils, land use or land cover. The satellite imagery is useful in recognition of linear features namely fractures or faults and palaeo -channels which are generally the zones of localization of ground water in hard rock and alluvial areas respectively. These characteristics indicate good aquifers.

Houston *et. al.,*(1977) remarked that the direct sensing of groundwater resources is generally impractical except for shallow aquifer surveys using induced polarization systems. Walker (1973) and Goetz *et. al.,* (1973) have applied the remote sensing imaging system as an effective exploration tool where groundwater occurrence is fault or fracture controlled in the Powder River Basin of Wyoming and Grand Canyon area of Arizona respectively.

The remote sensing technique has achieved importance as an indispensable tool for mapping and monitoring of natural resources (Kasturirangan *et. al.,* 1996). In India, an integrated approach of using remote sensing satellite data (IRS-1D PAN merged LISS –III) along with Survey of India topographical map, collateral information and limited field checks has provided base line information for identification of prospective zones of groundwater in various regions.

Geographic Information System (GIS) provides an excellent facility for the integration of various thematic layers for a quick and economical identification of the groundwater potential zones and is useful for generating hydrological and digital elevation models for developing groundwater information system at micro level (Shah and Singh, 2001).

Groundwater Indicators On Satellite Images

The remote sensing satellite data, in most of the cases, are unable to provide any direct information on groundwater. However, the surface morphological, hydrological-geological regime, which primarily governs the subsurface water conditions can be properly examined and mapped on the remote sensing data products. Hence, remote sensing acts as a very useful guide and an efficient tool for regional and local groundwater exploration

(Waters *et. al.,* 1990, Krishnamurthy *et. al.,* 1996, Singhal and Gupta, 1999 and Gupta, 2003).

Gupta (2003) recorded important indicators of groundwater observed on the remote sensing images (Table 1). The various surface features or groundwater indicators have been categorized mainly into two groups –

(1) First order or Direct indicators.

(2) Second order or Indirect indicators.

The first order indicators are directly concerned to the groundwater regime (viz. recharge zones, discharge zones, soil moisture and vegetation. The second order indicators are related to hydrogeological parameters which regionally the groundwater regime e.g., rock/soil types, structures, including rock fractures, landforms, drainage characteristics etc. (Gupta, op. cit.).

Table 1: Important Groundwater indicators on remote sensing data (after Ellyet and Pratt, 1975; Singhal and Gupta, 1999, and Gupta, 2003),

(A) First order or direct indicators

1. Features associated with recharge zones, rivers, canals, lakes, ponds etc
2. Features associated with discharge zones, springs etc.
3. Soil moisture
4. Vegetation (anomalous)

(B) Second order or indirect indicators

1. Topographic features and general surface gradient
2. Landforms
3. Depth of weathering and regolith
4. Lithology: hard rock and soft rock areas
5. Geological structure
6. Lineaments, joints and fractures
7. Faults and shear zones
8. Soil types
9. Soil moisture
10. Vegetation
11. Drainage characteristics
12. Special geological features, such as karst, alluvial fans, dykes and reefs, uncon- formities, buried channels, salt incrustations etc., which may have unique bearing on groundwater occurrence and movement.

Methodology For Groundwater Exploration

The groundwater exploration involves information on hydrogeological properties of various geological materials such as the porosity, permeability, transmissivity, storativity and specific yield. The relationship between different landforms, climate and their effect on weathering on geological materials and subsequently on groundwater occurrence and movement is equally important. The other significant factors in groundwater exploration include information on geological structures, recharge and discharge areas, relationship between drainage network and hydrological properties of rocks (Rao and Gupta, 1998).

Moore (1977, 1988) presented a concise account of the common methods and guidelines for delineation of potential aquifers. The presence of seeps and phreatophytes indicates the occurrence of shallow water table conditions, differentiation of vegetation that are also closely related to depth and salinity of groundwater, location and monitoring of groundwater under stress (Nag and Kudrat, 1998).

The Indian remote sensing satellites have proved considerable significance by providing more precise and reliable hydrogeomorphological information at regional level. The remote sensing imagery enables the recognition of various rock groups on the basis of factors such as spectral characteristics of rock types in conjunction with associated structural, drainage and geomorphic features (Hunt, 1980).

A careful attention should be given for the identification and interpretation of remote sensing imagery in respect of structural features such as fractures, faults and their intersection in hard rocks and certain synclinal structures providing clues for the location of groundwater in sedimentary terrain. The satellite imagery has helped in the mapping of landforms such as buried channels, valley fills, alluvial fans which are favourable indicators for the location of groundwater occurrence. The remote sensing data have received importance in analysis of the drainage pattern or palaeo-channels which have implications in the groundwater exploration programme.

In India, hydrogeomorphological maps of several areas have been prepared by using remote sensing technology (Sahai *et. al.,* 1985, Department of Space, 1988 and others). Nag and Kudrat (1998) described the method of hydrogeomorphological mapping (Figure 1) which involves following steps:

Step 1 : Base Map Preparation – The base map is prepared from the toposheets exhibiting ``general features such as important localities, roads, rail lines, rivers and drainage course.

Step 2 : Pre-Field Interpretation – It involves visual interpretation of satellite imagery to delineate various geomorphic features or landforms and their depiction on the base map. These geomorphologic features or landforms have been evaluated critically in terms of major lithology associated structural features, drainage patterns, soil types and their depth, thickness of weathered mantle in case of hard rock areas and the land use or land cover classes.

Step 3 : Ground Verification (Checks) – The existing geological maps and other ancillary data are supplemented by extensive field verifications.

Step 4 : Post -Field Interpretation – By integration of ancillary data (geology, lithology, land use, geomorphology and ground observations, hydrogeomorphological maps are prepared.

Srep 5 : Final Map Preparation - Final hydrogeomorphological maps are prepared by following methodology for final map preparation using visual interpretation of land use or land cover map.

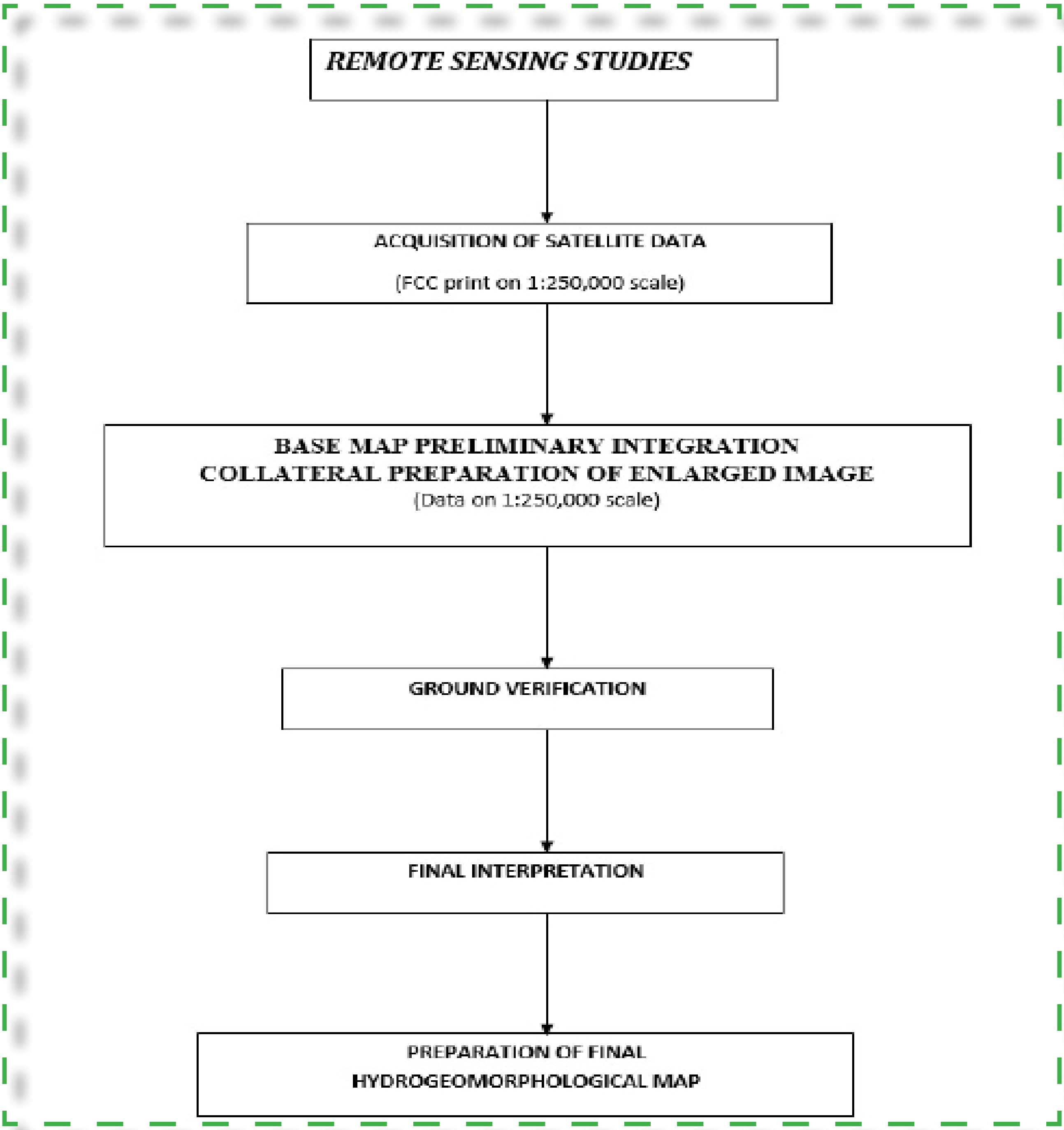
REMOTE SENSING STUDIES
ACQUISITION OF SATELLITE DATA
(FCC print on 1:250,000 scale)
BASE MAP PRELIMINARY INTEGRATION
COLLATERAL PREPARATION OF ENLARGED IMAGE
(Data on 1:250,000 scale)
GROUND VERIFICATION
FINAL INTERPRETATION
PREPARATION OF FINAL
HYDROGEOMORPHOLOGICAL MAP

Figure 1: Procedure of hydrogeomorphological map using remote sensing data. (Modified after Sahai *et. al.,* 1985, Nag and Kudrat, 1998)

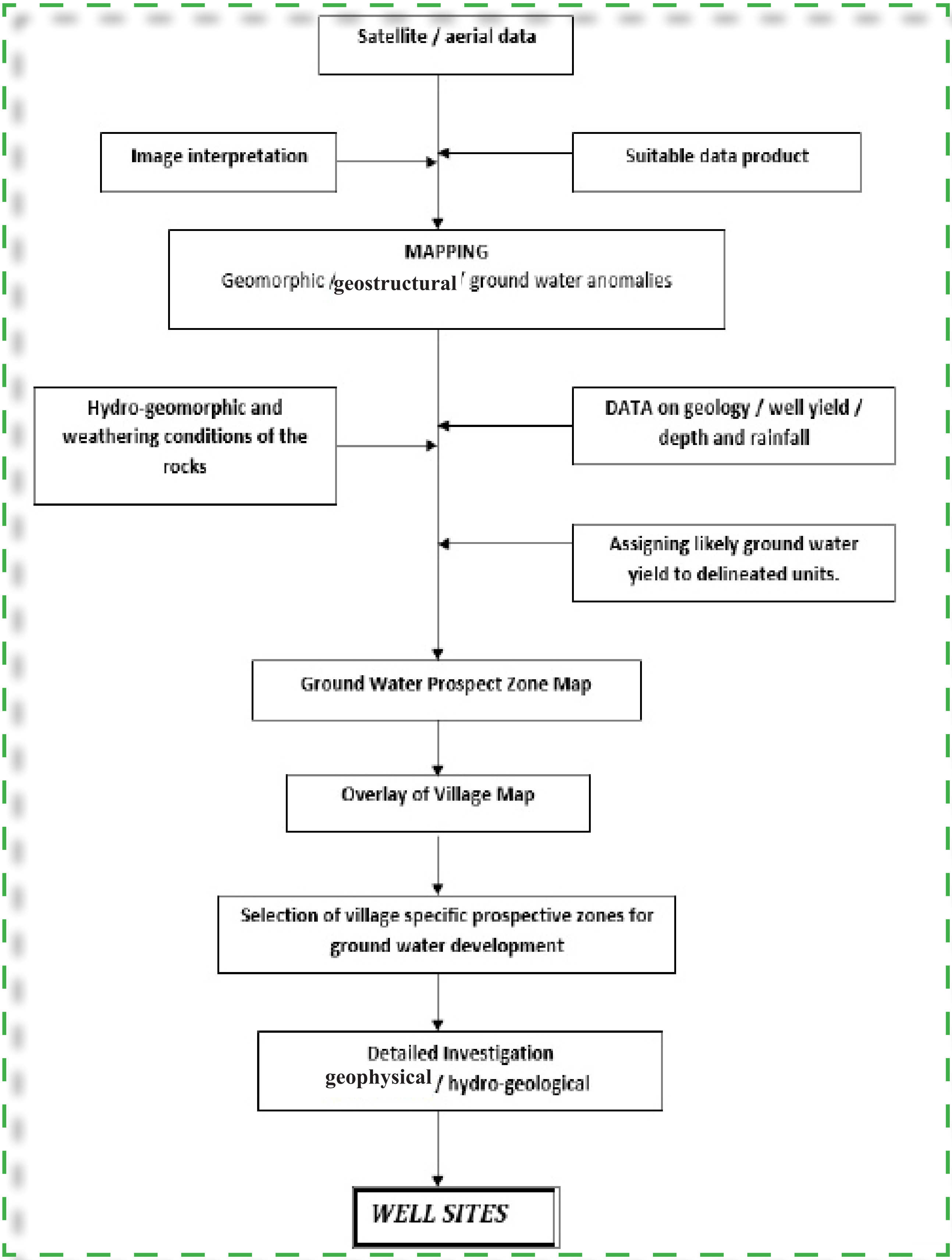
Satellite / aerial data
Image interpretation
Suitable data product
MAPPING
Geomorphic /geostructural / ground water anomalies
Hydro-geomorphic and weathering conditions of the rocks
DATA on geology / well yield / depth and rainfall
Assigning likely ground water yield to delineated units.
Ground Water Prospect Zone Map
Overlay of Village Map
Selection of village specific prospective zones for ground water development
Detailed Investigation geophysical / hydro-geological
WELL SITES

Figure 2: Satellite data based methodology chart for ground water prospect zone mapping (Modified after Rao and Gupta, 1998).

EXAMPLE OF SATELLITE DATA APPLICATION

The prime objective of groundwater investigation is the targeting of water resources for local water supply. The remote sensing techniques provide us valuable information which can be supplemented and verified by other field techniques. The integrated systematic approach of satellite sensor-aerial photographic-geophysical-drilling has been highly successful for the groundwater exploration. Basically, it reduces time factor, risk and expenditure in groundwater development (Gupta, 2003).

GROUNDWATER EXPLORATION IN HARD ROCK TERRAIN

The consolidated material - hard rocks comprise compact, cemented and crystalline rocks such as granites, sandstones, limestones, basalts, schists, and gneisses. The movement of groundwater in sedimentary rocks is governed by the presence of primary porosity and permeability, existence of faults, fractures, joints, bedding planes, etc. contribute to secondary porosity. In case of the limestones, it also depends on occurrence of sink holes, caverns, caves, solution tunnels, etc. The groundwater movement in limestone terrain is mainly due to secondary permeability. In the Deccan Traps, groundwater movement is controlled by the presence of vesicles and depth of weathering, joints and fractures. In general, igneous and metamorphic rocks yield rather poor groundwater reservoirs.

Hard rock terrain is characterized by secondary porosity and non-uniform flow of groundwater occurrence. The exploration strategy of groundwater involves identification of higher secondary zones such as fractures, faults, joints, weathered horizons, shear zones, vegetation, drainage anomalies and landforms.

The lineament analysis is of considerable value in groundwater exploration in hard rock terrain. It has been observed by Parizek (1976) that the wells located on fracture traces/lineaments recorded 10 to 1000 times more yield of water than those located away from fracture traces in identical conditions. The identification of suitable geomorphic unit is significant as features such as weathered zones, buried pediments and alluvial fills may form potential sites for groundwater targeting in hard rock terrain (Gupta, 2003).

RESULTS

The groundwater exploration using remote sensing and geographic information system techniques is a less time consuming and cost effective. The satellite data are helpful in the recognition of several groundwater indicators such as buried channels, lineament intersection zones, fracture controlled valleys, regional geological structure and vegetation which are generally not observed during the ground investigation. The remote sensing technique has proved importance in targeting suitable groundwater potential zones particularly in hard terrain.

Acknowledgement

Deep sense of gratitude is recorded to Dr.V.K.Panchal, Scientist 'G', DTRL, DRDO, New Delhi, for encouragement and inspiration.

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Human Perception And Response To Flood Hazard: A Case Study In Bibikulam Area Of Madurai City, Tamil Nadu

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Abstract

Floods, which come under natural phenomena, are one of the most dramatic interactions between Man and his environment, (Ward. R. 1978) Floods are among the most common and destructive natural hazards causing extensive damage to infrastructure, public and private services, the environment, the economy and devastation to human settlements According to the HPC Report of Government of India , around 75% of the total rainfall is concentrated over 4 months of monsoon and as the result almost all the rivers carry heavy discharge during this four months. Madurai, one of the rural based urban centers located on the banks of river Vaigai , is affected by floods frequently. The expansion of the city in the flood prone area is unavoidable due to the increasing population and urbanization processes. The city has a population of over a million persons as per 2011 census. Once it was dotted with number of small and big tanks in and around city. But now a significant number of tanks have already been encroached both by the Government and the public. A maximum number of channels draining water from these tanks have also been occupied without giving space for rain water to get drained. Sellur a part of Madurai city is one of the flood affected area. Hence Bibikulam area in Sellur has been selected for the present study to make suggestion for the effective flood management based on the perception and response of the residents. The study mainly focuses on the socio-economic characters of the respondents, flood damages, perception and response of the responses using GIS.

Key Words: Hazard, GIS, Madurai, Flood damages and Perception.

Pages: 9 References: 13

INTRODUCTION

A physical event, such as a volcanic eruption that does not affect human beings is a natural phenomenon. A natural phenomenon that occurs in a populated area is a hazardous event. Hazardous events that cause, unexpectedly, large numbers of fatality or overwhelming property damage are a Natural Disaster. In areas where there is no human interest, natural phenomena do not constitute hazards nor so they results in disaster. Natural hazard will hence never result in natural disaster in areas without vulnerability for example strong earthquake in uninhabited areas. Natural hazard is an event that will have negative effect on peoples or environment. Human intervention can increase the frequency and severity of Natural Hazard and also reduce the mitigation effect of the natural system.

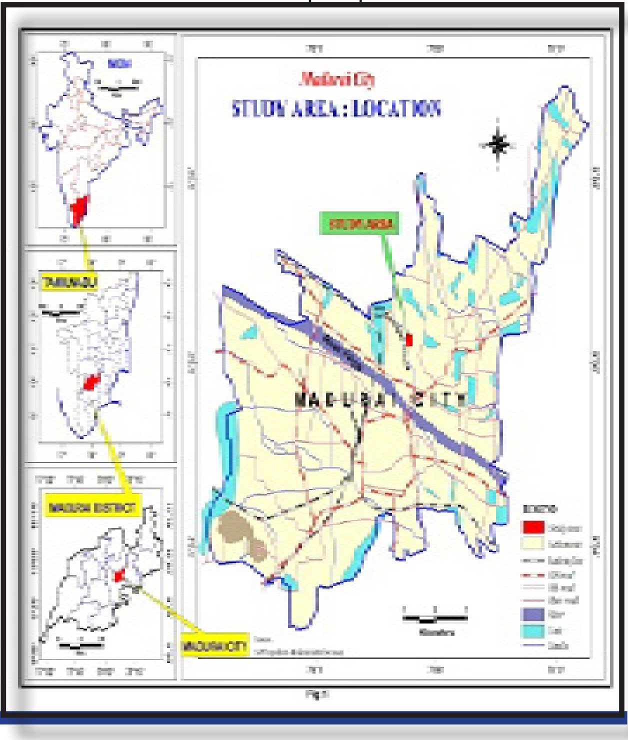
FLOOD HAZARD

Physically a flood is high flow of water which overtops either the natural, of the artificial, bank of a river. However such an event cannot be described as a hazard unless it threatens human life and property. Floods, which come under natural phenomena, are one of the most dramatic interactions between man and his environment (Ward. R, 1978). Flooding is one of the common hazards that causes loss of life and properties of the people and even causes severe economic setback, especially in developing countries (UNDP,1999).

Floods are among the most common and destructive natural hazards causing extensive damage to infrastructure, public and private services, the environment, the economy and devastation to human settlements. Floods usually are local, short-lived events that can happen suddenly and sometimes with little or no warning.

In India, flood is always recurrent phenomenon. According to the HPC report of Government of India , around 75 per cent of the total rainfall is concentrated over 4 months of monsoon and as the result almost all the rivers carry heavy discharge during this four months. Floods are caused due to Monsoon rain for a short period which in turn causes consequent heavy water discharge in channel, tank and river and damage to crops and infrastructures. About 40 million ha of land is flood prone, which is about 12 per cent of the total geographical area of the country. Annually 8 million hectares of land are affected by flood (Chawla, 2008).

The frequency and intensity of floods has grown in the country over the years primarily because of the increased encroachment of flood plains. Interestingly the number of deaths caused by flooding has decreased over the last decade, while the number of affected populations and economic losses has increased significantly. These trends demand better preparedness at national, provincial and local levels to make sure that appropriate and effective response measures are taken during flood emergency to minimize the loss of lives and properties.



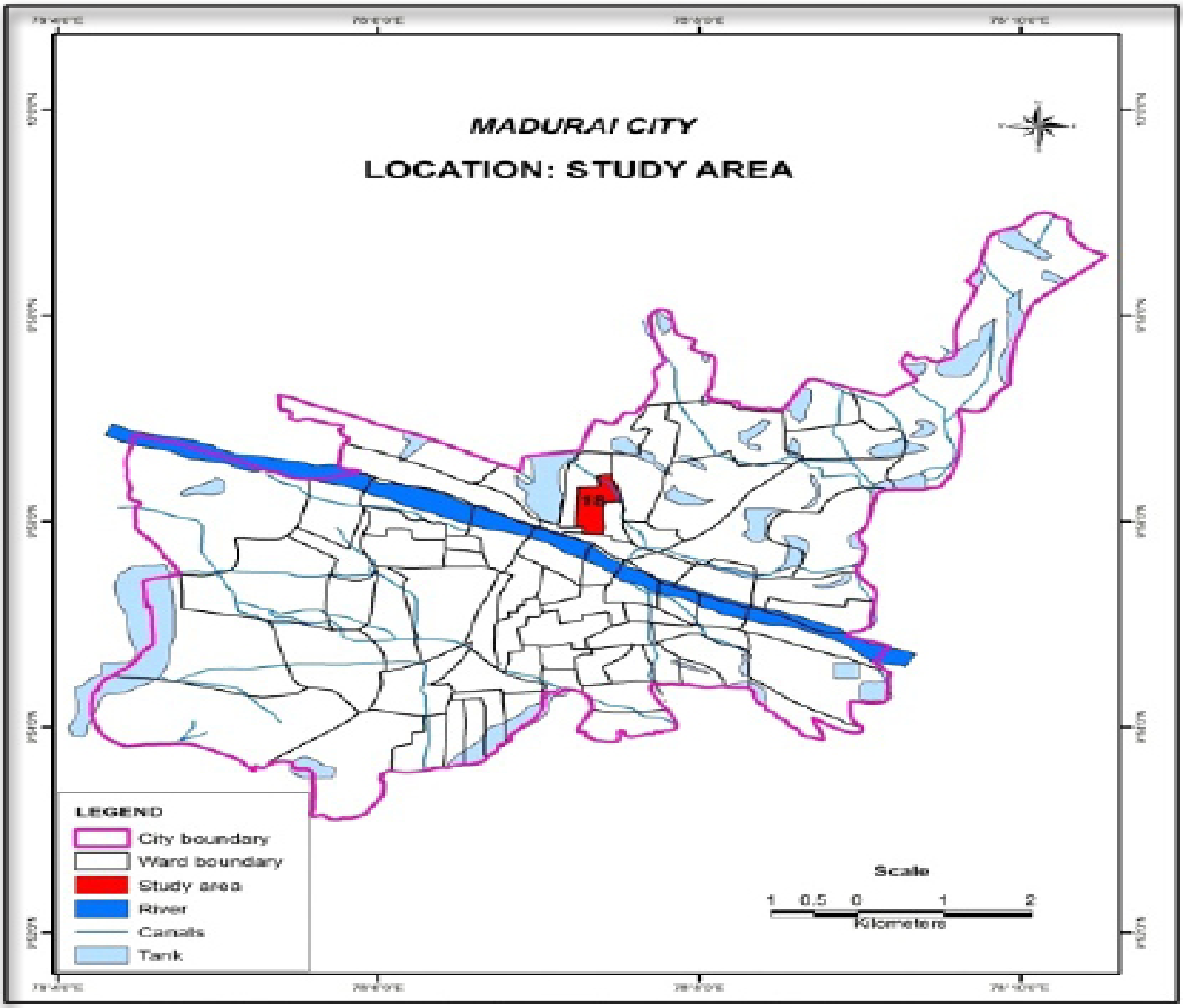


Fig. 1

More than 50 million of people live in cities, and due to high concentration of people, buildings, infrastructure and socio-economic activities in the cities, there will be tremendous losses and damage when such a severe flood strikes.

Madurai, one of the heritage cities of Tamilnadu is selected for this study. Flood management strategy is not new to Madurai. Before, during & after Sangam period flood was the most devastating hazard for Madurai city. Thiruvilaiyadal Puranam and Paripadal emphasized the effect of flood and explained how people managed that situation. Pittukku Man Samantha padalam explains how Lord Shiva took the form of an ordinary labourer to construct an embankment across the river Vaigai and thereby prevent the flood.

Madurai is an ancient and prestigious city, in Tamilnadu, situated on the banks of river Vaigai, has experienced a number of floods (Fig. 1). Madurai city with 52 km^2 area is located at 9°93´N 78°12´E. It has an average elevation of 101m above MSL. The climate is hot & dry with North East monsoon rains during October-November. Temperature during summer reaches a maximum of 40°C and a minimum of 26°C. Winter temperature ranges between 18°-29°C.

The average annual rainfall is about 85cm. Heavy and prolonged rainfall is the most common cause of floods during monsoon season in Tamilnadu especially in Madurai district. Not only in the monsoon, River Vaigai, are the streams, tanks the major sources for flood in and around Madurai. The hills in the north also add the water during the rainy season. The Sellur and its surrounding in the north of river Vaigai is one of the frequently flood affected areas because of their low lying nature. The overflowing Sathaiyar dam and Sellur tank increase the overflow of water in Panthalkudi channel, which affected the people in Sellur and its environ. Due to encroachments of building structures in the flood plain areas, people suffer a lot during the rainy season. During the 2005 flood of Sellur, Bibikulam area was one of the worst affected for the local people's life and properties. The participation of Government and NGO at the time of flood was timely one but not a permanent management, the present study can give suggestion to minimize the loss.

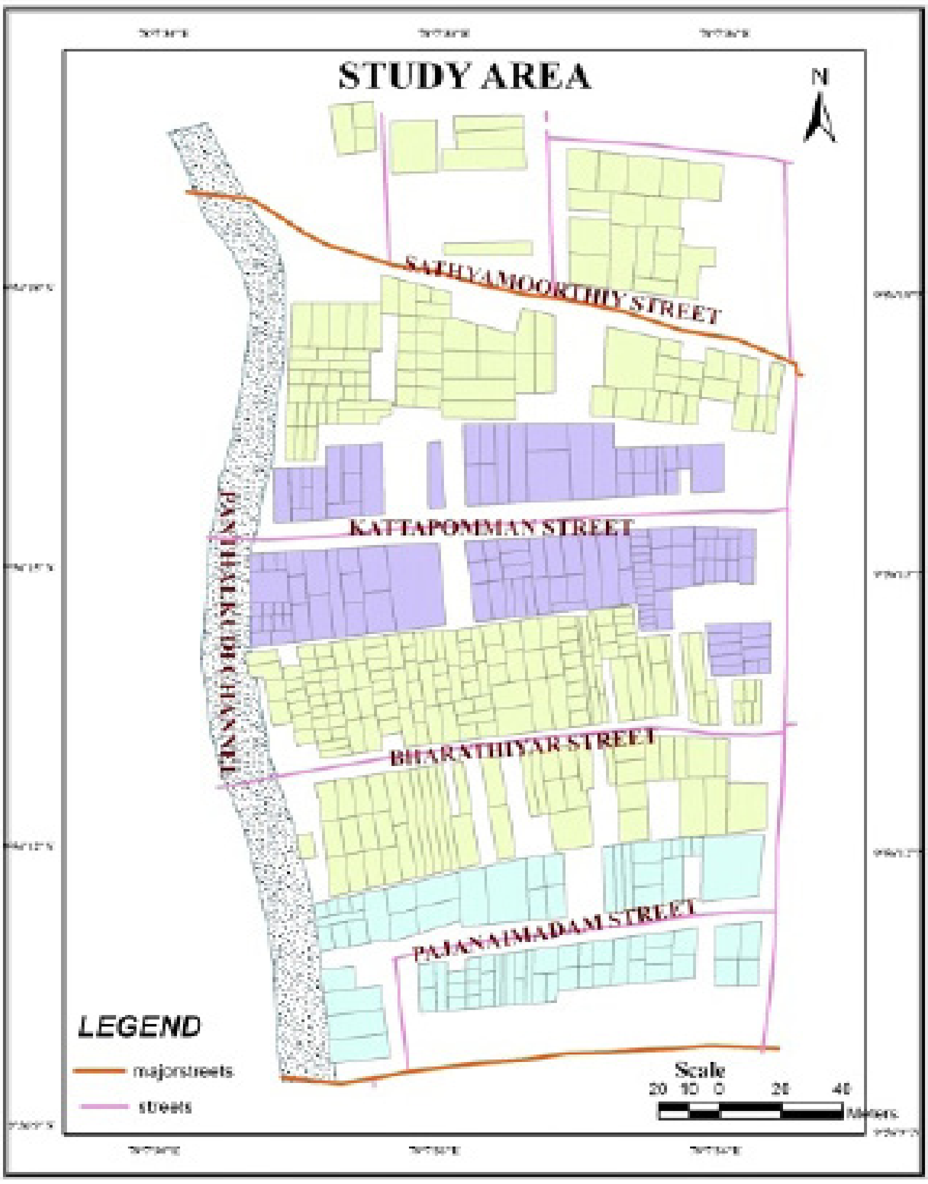


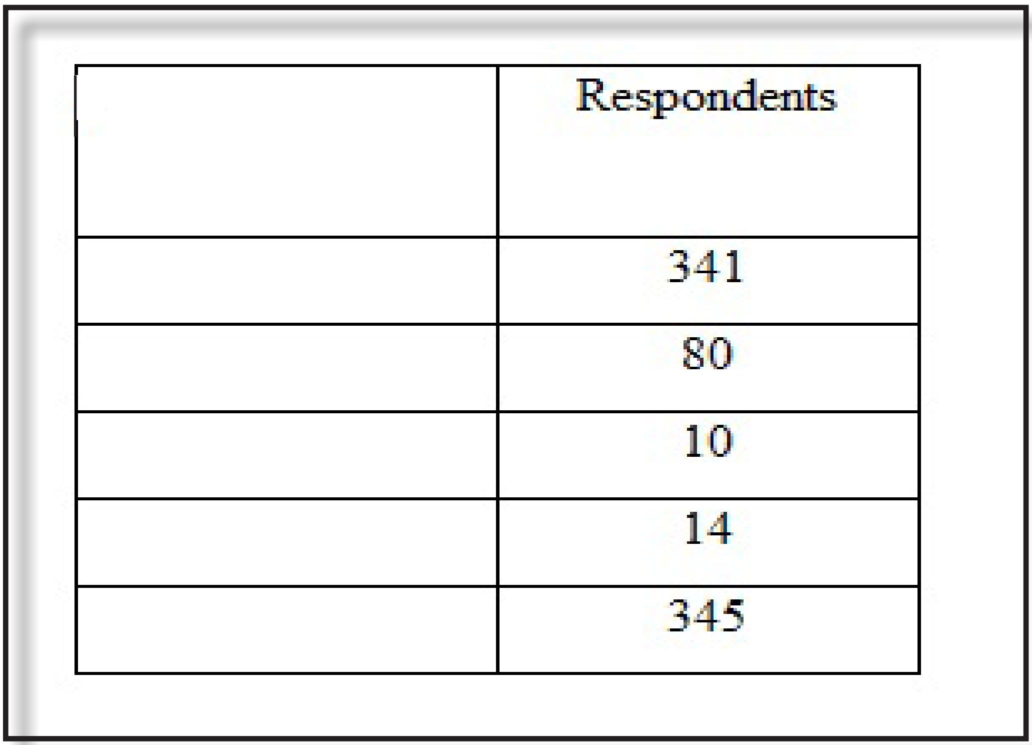
Fig. 2

METHODOLOGY

Bibikulam, a part of the Sellur area, close to the Panthalkudi channel is selected for an intensive study (Fig.2). To find out their socio-economic conditions, perception and response Primary Data (by 445 questionnaires) was collected from Sathiamoorthy street, Kattapomman street, Bharathiar street and Bajanaimadam street of Bibikulam which comprises of 475 households. The questionnaire comprises 18 different questions, which will reflect the various socio-economic conditions of the respondents. A Geo-data base has been created for this area 58k/1, 58k/1 NE&NW, Survey of India Topographical sheet, Google Earth Satellite Imagery have been used for the preparation of base and other maps to analyze the data with GIS base. The application of Arc GIS is a significant tool for gathering suitable information by making queries. Maps are prepared on the basis of that.

RESULT AND DISCUSSION

The questionnaire was tabulated and analyzed. Since this area is encroached recent past from rural area maximum population come under the illiterate category followed by matriculates and primary level literates. Among the respondents 39 per cent are daily wage earner, 28 per cent are other workers like vegetable venders tri – cycle puller etc.18 per cent are business peoples and 15 per cent are salaried peoples. The income level is very low in this area because major respondents are daily wage earner. About 77 per cent of the respondents comes under very low income group that is Rs. 5000 per month while 18 per cent come under 5000- 10000 income.



	Respondents
	341
	80
	10
	14
	345

Fig. 3

The houses which are located in the low lying areas are affected by flood. Only 117 houses reported flood water stagnation in which 50 houses are below 3 feet flood water stagnation and 26 houses are above 3 feet flood water stagnation.

Table: 2 Flood Damage

Damage in Rs.	Sathayamurty Street	Kattapomman Street	Bharathiyar Street	Pajanaimadam Street	Total
<5000	5	20	33	13	71
5001-10,000	9	2	6	2	19
>10,000	2	7	5	4	18

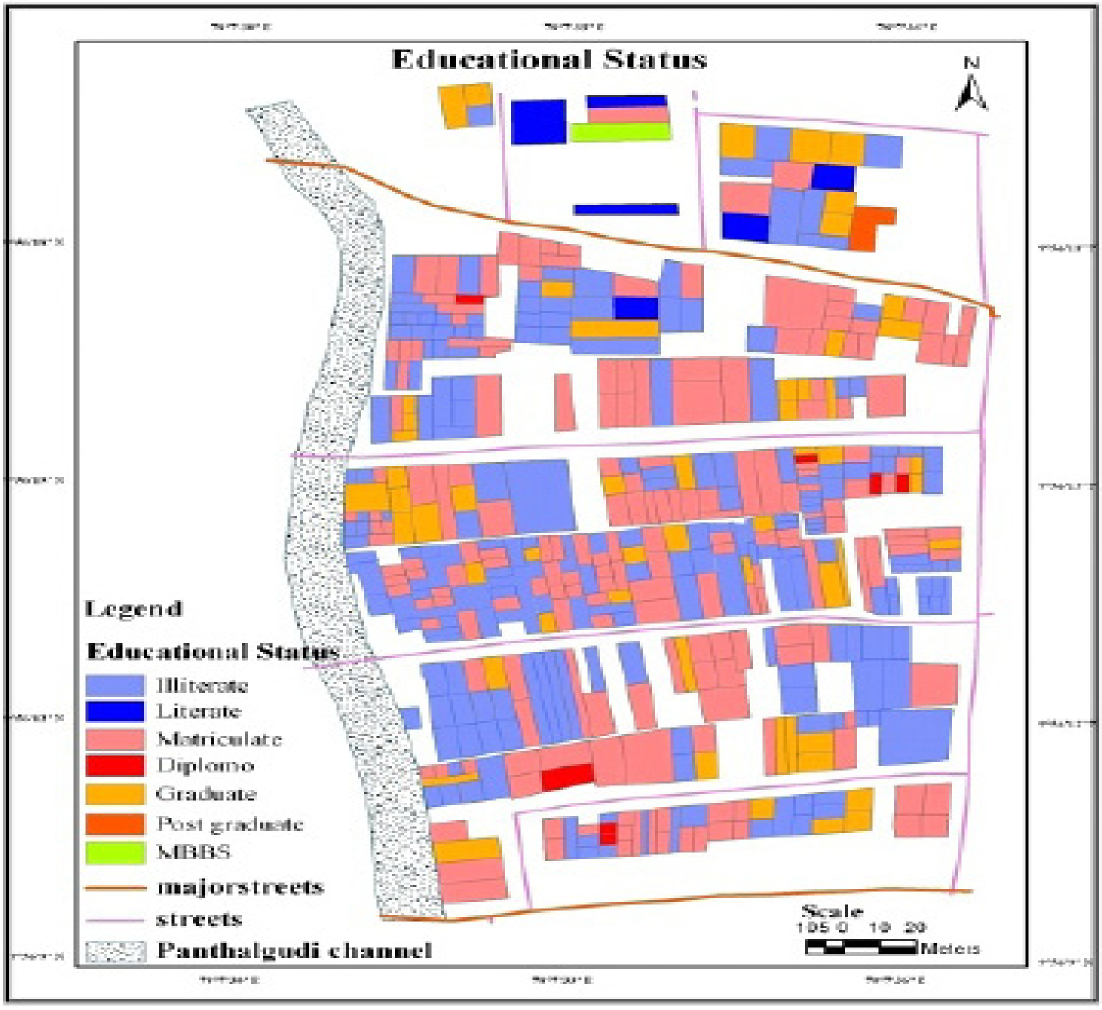


Fig. 4

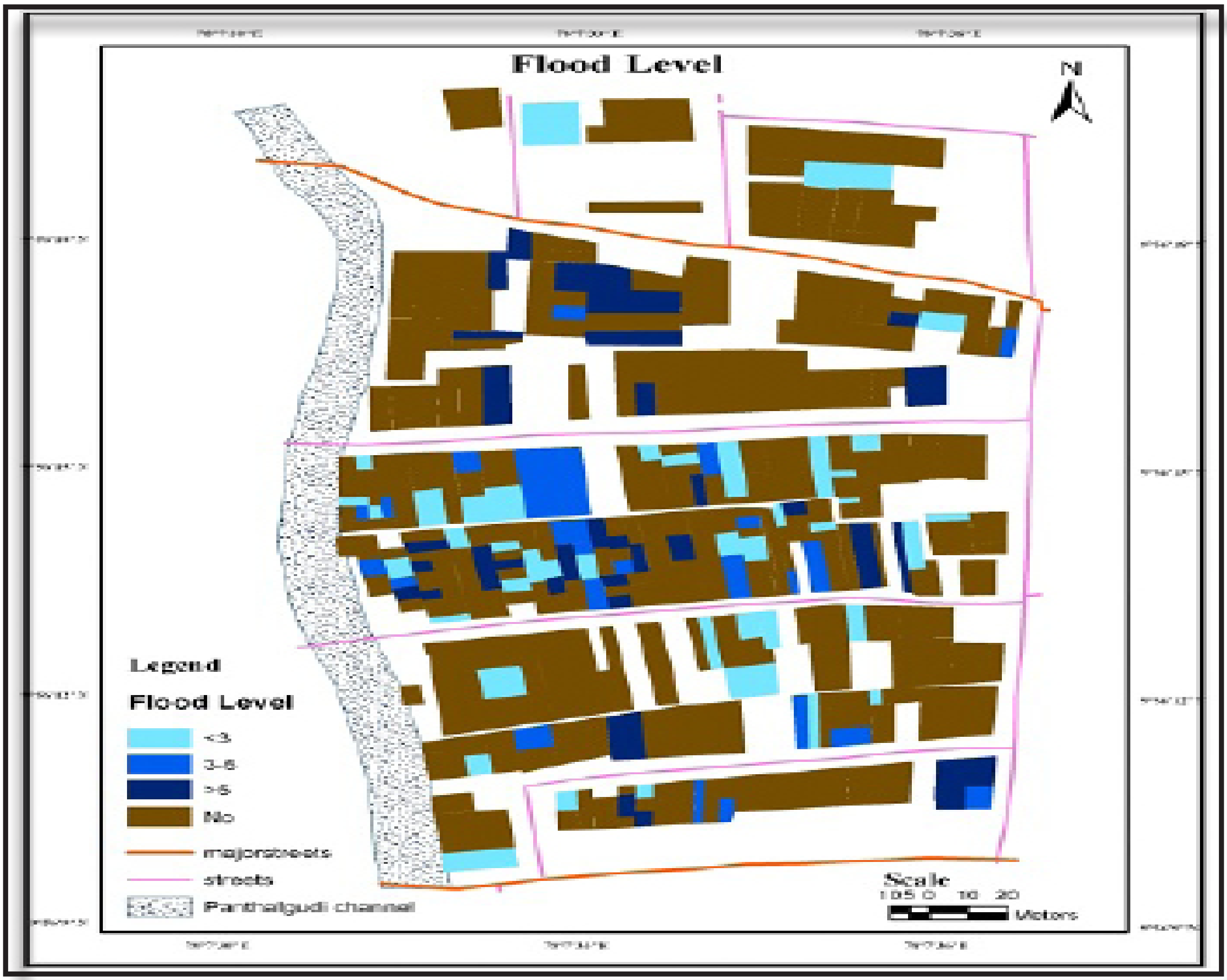


Fig. 5

There is no life loss, but property loss happened. About 108 houses reported considerable damage for their properties (Table 2). The flood water stagnation is only for 2- 3 days and not more than that. Flood is not a frequent occurrence but an occasional phenomenon according to the residents of Bibikulam area.

The low lying nature of the area and its proximity to the Sellur tank are the main reasons for flood occurrence. But the perception is that, flood is inevitable but controllable by means of structural adjustments. Nearly 70 per cent of the respondents predict floods in the future while the remaining expects no floods. Most of the respondents, nearly 60 per cent learned about the flood warning through Radio, T.V, Government announcements and Newspapers. Majority of the population is in favour of changing the socio-economic condition of the area. The govt. aid during the flood period is insufficient for them.

They are in the opinion that government should raise the tank and channel embankment levels, desilt the drainage channel periodically, and raise the floor level of building structure. They will not evacuate themselves from the area at any cost because most of them are economically poor and they want to remain in the same area. Most of the respondents are tenants.

CONCLUSION AND RECOMMENDATIONS

The present study exhibits the socio- economic characters of the respondents, their perceptions and response. Various measures should be adopted during the time of flood hazards. The following measures are suggested to be included in the future plan to mitigate the flood hazard in the Bibikulam area of Madurai city.

* Effective ,improved and timely warning system should be activated.
* Storm drain should be constructed in all areas prone to floods, so that rain and flood water do not stagnant for long time.
* The proposed new channel should be completed at the earliest to drain the excess discharge water from Sellur tank to river Vaigai.
* Proper evacuation plan for the people living in low lying areas is needed, and
* Adequate relief and rehabilitation measures are required.

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Characterization and Mapping of Inland Wetlands using Remote Sensing and GIS (A case study on the selected sites of Nadia District, West Bengal)

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Abstract

Šustainable management of wetland ecosystem is necessary as it serves the important functions such as food storage, water quality maintenance and providing habitat for different species of wildlife. Hence, an inventory of wetlands in any given area is a pre-requisite for their conservation and management. A study has been carried out to delineate the wetlands of Nadia district of West Bengal, India, using IRS ID LISS III data of the year of 2000. The data have been analysed and the wetlands have been qualitatively characterized based on the turbidity and aquatic vegetation status. The two categories of wetlands (ponds/lakes, and oxbow lakes) have been identified. From the analysis, it has been observed that the inland wetlands constitute 3.5 % of the study area, of which 2.8 % is subjected to Ox-bow lake which is locally called as bils. Thus, this study highlights the usefulness of remotely sensed data for wetland mapping, seasonal monitoring and characterization.

Key Words: Remote Sensing, LISS-III, NDVI, Image Processing, Wetland Characteristics and Mapping.

Pages: 13 References: 14

INTRODUCTION

Wetlands play a significant role in maintaining environmental stability in a world where environmental degradation is increasing day by day. They render innumerable services like food storage, water quality maintenance and livelihood in terms of fisheries and recreation (Hollis and Acreman, 1994). ft is therefore necessary to make an inventory of wetlands in an area, which will enable us to monitor the changes that are occurring due to human interference over a period of time. In some of the earlier studies, remote sensing techniques were used for deriving information on the quantitative and qualitative status of wetlands (Carpenter and Carpenter. 1983; Mutiny *et. al.,* 1988; Palria *et. al.,* 1994; Wani *et. al.,* 1996; Chopra *et. al.,* 1999). Most of these studies have focussed on individual wetlands. Thus, an overall estimate of the condition of wetlands over a large area is useful for "conservation of wetlands. Garg *et. al.,* (1998) have carried out study to delineate wetlands of a number of districts across India using IRS- 1A/B LISS J/II data. This study was carried out on a large scale, only the wetlands of area greater than 56 ha. were mapped on !: 250,000 scale. However, an overall estimate of the condition of wetlands over a large area at higher resolution is useful for wetland management. Conservation of wetlands is essential because of its productive and retentive uses such as supplementing human dietary requirements, ecological significance in terms of flood control, water purification, aquatic productivity and microclimate regulation. Realizing the importance of the wetlands, the present study was taken up with the specific objective of delineation and characterization of wetlands in terms of turbidity and aquatic vegetation, using digital image processing technique. The seasonal variation of the Water spread for the mapped wetlands was also carried out. The present study covers wetlands of area greater than 2 ha. on 1:50000 scale. These are extremely important habitats for many species of migratory birds.

STUDY AREA

Nadia is located between 22°53” and 24°11” North latitude and 88°09” and 88°48” East longitude and about 390027 Sq Kms(Fig: 1). in Area, this District is linear in shape with orientation of North-South. The District is Approximately 46 ft. above the mean sea level. The Tropic of cancer divides the district in two parts. The geographical boundary of Nadia district comprises Bangladesh in the East, Bardhaman and Hugli district on the West, Murshidabad district on the North and North West and North 24 Parganas towards South and South East. Situated on the main rail route connecting Howrah/ Kolkata and New Jalpaiguri(NJP) including parts of North Eastern states, the Nadia district can easily be accessed by rail. The major railway stations are Nabadwip Dham, Ranaghat and others with regular trains to Kolkata/Howrah/NJP/Guwahati. The proposed International Rail Link connecting India and Bangladesh will pass through Nadia District with Gende as the last railway station at Indian Border. Bifurcated by National Highway-34 on the North and East, the district can also be accessed by road from other parts of the country.

MATERIALS AND METHODS

Data Used

IRS-1D LISS III data (Path 108/Row 56) of November 2000 (Post – monsoon season) are used in the present study. The IRS-1D LISS III image is geometrically rectified to extract the data pertaining to the study area (Fig. 1). The digital image processing was carried out using ERDAS IMAGINE software and the GIS analysis is carried out using TNT Mips software. The methodology proposed by RRSSC (2000) was adopted in the present study. In order to map and classify the different inland wetland classes, FCC of water bodies was generated from the FCC of the study area. Further, the turbidity and aquatic vegetation status of the wetlands are characterized into three levels namely low, medium and high. For analyzing and mapping ERDAS IMAGINE (9.0) and TNT Mips 2009 s/w are used.

Delineation Of Wetlands

Various digital image processing techniques such as thresholding, modelling technique and classification are available for delineation of water bodies (Nagarajan *et. al.,* 1993; Sharma *et. al.,* 1996). In the present study thresholding technique was adopted. Threshold is a technique where the entire gray values occurring in the image are divided into a series of analyst specified intervals. All the gray values falling within a range are grouped in one gray value, which is displayed in output. The process divides the image into water and land pixels. From the study of histogram peaks, minimum and maximum value for water pixels is identified and image is density sliced. Thresholding can be performed on single or combination of bands. The near IR band of LSS III data is used for delineating the water bodies in this study as the spectral reflectance characteristics of water are clearly separable from other signatures in (his band having wavelength range of 0.77 - 0.86 µm Hence, the near IR band data of LISS III is used and is density sliced interactively with (he study area FCC, such that the pixels having gray values corresponding only to the water bodies are identified. From this water body mask the wetlands having area less than 2 ha. were removed using the routine functions of the image processing software. Further, it is observed that while using this method some regions having cloud shadows are failing within the water mask. In addition, certain wetland areas having aquatic vegetation are not included under the mask Hence the water body mask is refined by examining the mask in conjunction with the FCC of the study area. Thereafter, the FCC having only water signature is extracted from the FCC image of the study area using the water body mask (Fig. 3). The extracted wetlands are then classified into different types of wetlands such as ponds/lakes, reservoirs, oxbow lakes and waterlogged areas. Finally, the land use/land cover map of the study area was generated by supervised classification technique. The integrated land use/ land cover map of the study area was generated by overlaying the classified wetlands on the Land use and land cover map(Fig. 2).

ACKNOWLEDGEMENTS

Classification of Wetlands based on Turbidity

The wetland water quality has to be maintained in order to sustain the wetland ecosystem. Often, the turbidity level in any wetland is indicative of the quality of the water in it. In the present study, inland wetlands are characterized in terms of their turbidity level as it is important for wetland conservation The red band (0.62 - 0.68 m) of LISS III data is found to be useful for turbidity classification (2000), as spectral reflectance characteristics of pure and turbid water are clearly separable in this wavelength range. In this study, the red band data of the extracted water body FCC is used, which is further density sliced into three ranges corresponding to three levels of turbidity, viz., low, medium and high. This is done in conjunction with the extracted water body FCC. The deep blue portions in the FCC correspond to low turbidity while the lighter shades of blue correspond to higher levels of turbidity (Garg *et. al.,* 1998). In the present study, these limit of the grey values for low, medium and high turbidity classes were observed to be 53, 67 and 112, respectively. Though, the fixing of the threshold is based on visual interpretation of raw data, the threshold count is likely to change with different overpass dates, and need to be fixed data independently. In this present study four bils (Alakananda Bil, Hansadanga Bil, Bhaluka bil, Noapar Bil)are selected as sample site(Fig. 4).

The first author (prof. M.V. Subba Rao) is thankful to the Ministry of Environment and Forests, Government of India, New

Delhi for financial support. The second author (VVS) who worked as a JRF in MoEF project for Doctoral degree under the guidance of prof. M.V. Subba Rao. Thanks to the authorities of Andhra University for facilities and encouragement.

Classification of Wetlands based on Aquatic Vegetation

The aquatic vegetation in a wetland is an indicator of the tropic status of the wetland, which has a bearing on water quality. Thus the excessive presence of aquatic vegetation viz., eutrophication. not only deteriorates the water quality but also affects the stability of the ecosystem. Therefore, it is essential to monitor the level of aquatic vegetation in a wetland at regular intervals. The qualitative status of the aquatic vegetation in the wetlands is estimated using the Normalized Difference Vegetation Index (NDVI) (Fig. 5). The NDVI is a parameter, which gives a measure of the vegetation density in any area (Tucker and Sellers, 1986). It is based on the fact that healthy vegetation reflects well in the N1R part of the spectrum. Green leaves have a reflectance of- 20% in the visible range and - 60% in the near infra-red (N1R) range (Loveland *et. al.,* 1991). In the present study, the NDVI image is generated specifically for the water body FCC. The NDVI is defined as (Tucker, 1979),

$$\mathrm{NDVI} = (\mathrm{N1R} - \mathrm{R})/(\mathrm{NIR} + \mathrm{R}) \qquad \mathrm{EQ.\ 1}$$

where, NIR and R are the near infrared band and red band reflectance values respectively. The possible range of values of NDVI is between -0.1 and 0.6 (Perry and Lautenschlager, 1984). In the present study the NDVI values of water bodies(Fig. 5) ranges from -0.28 to 0.50. Further, the NDVI image is density sliced into three levels namely, low (<=0.05), medium (>0.05 and <0.2) and high vegetation density (>0.2) corresponding to “NDVI values and also in conjunction with the extracted water body FCC in the background. However, these threshold limits can be changed as per individual choice. In general the regions having bright red hue correspond to high vegetation coverage.

RESULT AND DISCUSSION

Classification of wetlands

The land use / land cover zones along with different wetland classes for the post monsoon season has been classified in ERDAS Imagine 9.2 software(Fig.2). The general land use classes is found to be covered almost 82% of the total district area. The most prominent inland wetland class found in the study area is that of waterlogged areas followed by oxbow lakes. The inland wetlands together constitute, - 2.7% (107.35 km^2) of the area, of which as much as 78 km^2 comes under water logged areas. This shows that water logging is a significant problem in the study area, which may be due to the fact that the terrain is mostly plain. Further, the water spread is examined using the post monsoon data (as per the image acquisition date) of the study area. A reduction in the water spread during post monsoon season is found to be around 69 km^2 (around 65%) in comparison to the post-monsoon season. The maximum reduction in water spread of 55 km^2 is observed for the water logged areas out of 69 km^2 reduction for all the wetlands. It is also observed that most of the areas remains waterlogged for almost nine months affecting the agriculture. This seasonal change in water spread area may be attributed to rainfall pattern, topography and poor drainage facilities in the area. Further, it was also observed that the intense agricultural activity in the study area has led to the excessive use of fertilizers, which eventually find their way to the wetlands causing eutrophication. The increased agricultural activity; particularly in the vicinity of the wetlands, may be one of the reasons for decline in the number of migratory birds in the wetlands.

Turbidity Status for different Wetlands

Multispectral satellite data provides invaluable synoptic data on the dynamics of wetlands such as turbidity and aquatic vegetation. The turbidity levels for the different wetlands of Nadia district have been qualitatively characterized into three levels namely, low, medium and high. It is observed that as much as 93.79% of the area is under moderate to high turbidity. The post-monsoon turbidity pattern for the different wetlands is shown in the turbidity levels are found to be tower for the oxbow lakes as compared to the other wetlands. The turbidity levels are found to be higher in the post monsoon data. The percentage of area under medium and high turbidity has gone up significantly, while that under low turbidity has reduced to 6%. The increased turbidity level in the post monsoon data is attributed to the sediments and silt that have been transported into the wetlands along with runoff water. Here(Fig.6) using Transect Extraction Technique Reflectance curves are generated for each of these four water body FCCs. After that the Reflectance curves are analyzed for the gradation of bils according to its turbidity level. The turbidity nature of the bils are discussed(Fig.6).

In case of Noapara bil at krishnanagar II the profile view shows(Fig.6) this reflectance curve. So we can state that where red reflectance is so less than the infrared reflectance and the green reflectance is so high than the others. On the basis of these we can say that the turbidity level as well as the eutrophication rate is high over here.

But in case of Hansadanga bil at krishnanagar –II the profile shows(Fig.7) that the green, red and infrared reflectance are so high in a part and on the another part infrared is low than the other two, so we can state that here the concentration of aquatic flora is high but the chlorophyll concentration is low, cause of insufficient oxygen.

In case of Alokanande bil at Krishnanagar –I the profile view shows(Fig.8) the infrared reflectance is high than the red and green reflectance curve. So we can state that the turbidity level and eutrophication rate is high in this area.

But in case of bhaluka bil at Nabadwip the profile view shows(Fig.9) that at the beginning the high reflectance of infrared shows clear type of water but just after that high red reflectance shows the medium turbidity level of water.

Qualitative Status of Aquatic Vegetation

The post - monsoon aquatic vegetation distribution for different wetlands which clearly shows(Fig.5) that nearly 87% of the area of wetland corresponds to low vegetation density category. High vegetation density coverage is found to be around only about 5% of the wetland area. It is seen that the level of aquatic vegetation is higher for the oxbow lakes as compared to other wetland types. Thus, a high level of aquatic vegetation density would indicate the possibility of the water being eutrophic. This may be attributed to the excessive growth of aquatic vegetation caused by excess input of organic and inorganic nutrients into a wetland. The percentage of area under low vegetation has gone up substantially in the post monsoon season. The percentage of area under medium vegetation has reduced by more than half and that under high vegetation has marginally gone up. Thus, the overall picture seems to indicate a reduction in the aquatic vegetation for the post monsoon season.

The digital indices analysis for the aquatic vegetation (Alakananda Bil, Hansadanga Bil, Bhaluka bil, Noapara Bil) of selected sample site(Fig.5) is clearly showing that, the NDVI value is ranging from 0-1 and which is segregated in 4 categories. Among which the clear water is demarcated by the volume of 0.0, the moderately turbid water is demarcated by the value of 0.247059, and as it is tending towards 1, the vegetative content is getting high, as per the output 0.498039 and 0.74902 shows the high concentration of aquatic vegetation.

CONCLUSION AND RECOMMENDATIONS

In the present study, delineation and characterization of wetlands was carried out using digital image processing techniques. The spatial and temporal characteristics of wetlands in terms of turbidity and aquatic vegetation could serve as guiding tool, in conservation prioritization of wetlands. Specifically, the spatial distribution of aquatic vegetation in terms of different density levels gives an indication of the trophic status of the area concerned. Thus, periodic monitoring of wetlands for large administrative units like districts will efficiently bring out the changes in water spread and quality parameters for adopting necessary conservation measures. Moreover it could pave the way for a detailed assessment of the problem in a relatively shorter duration.

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Appendices

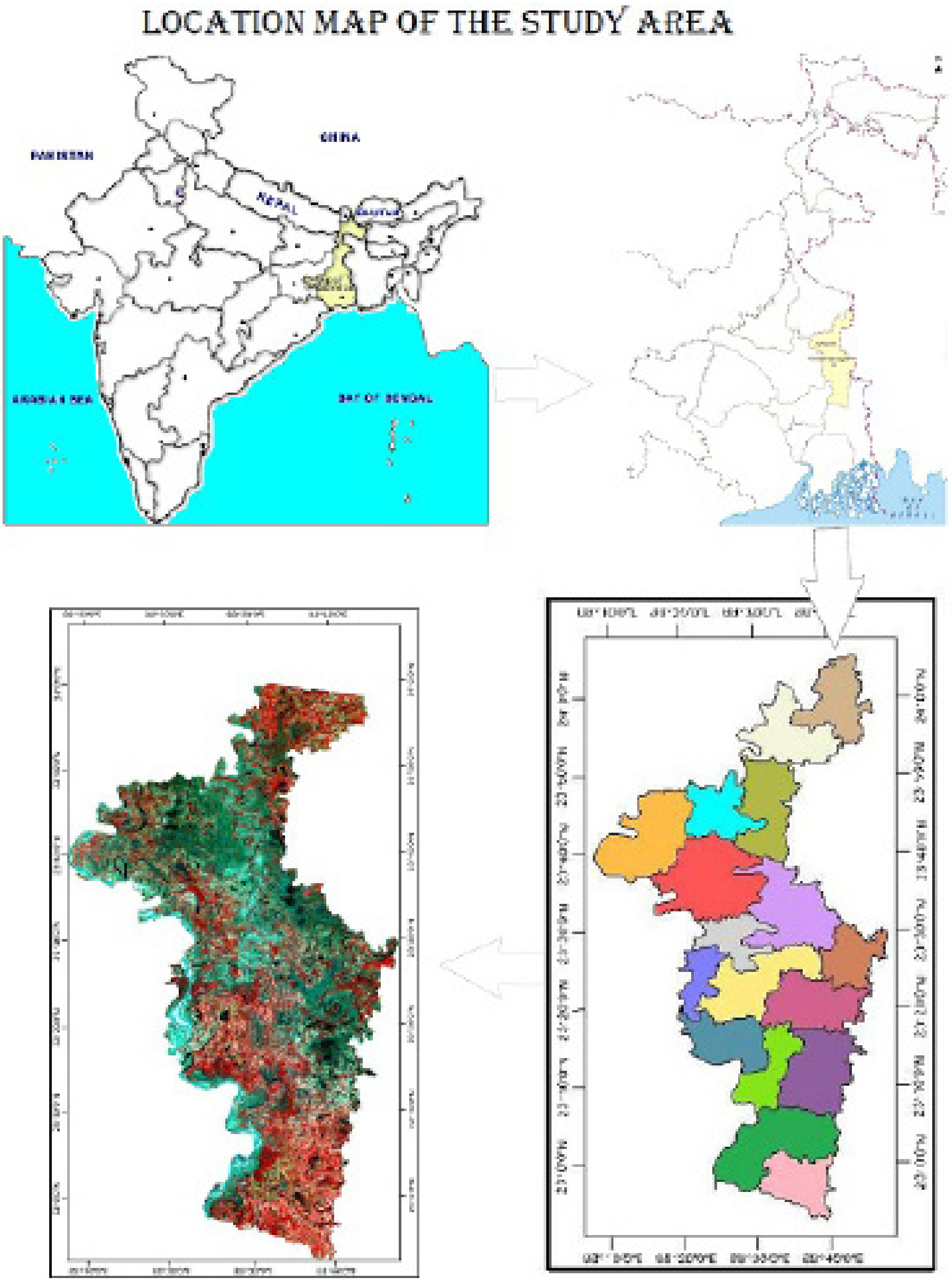

Fig. 1: Location Map of the study area

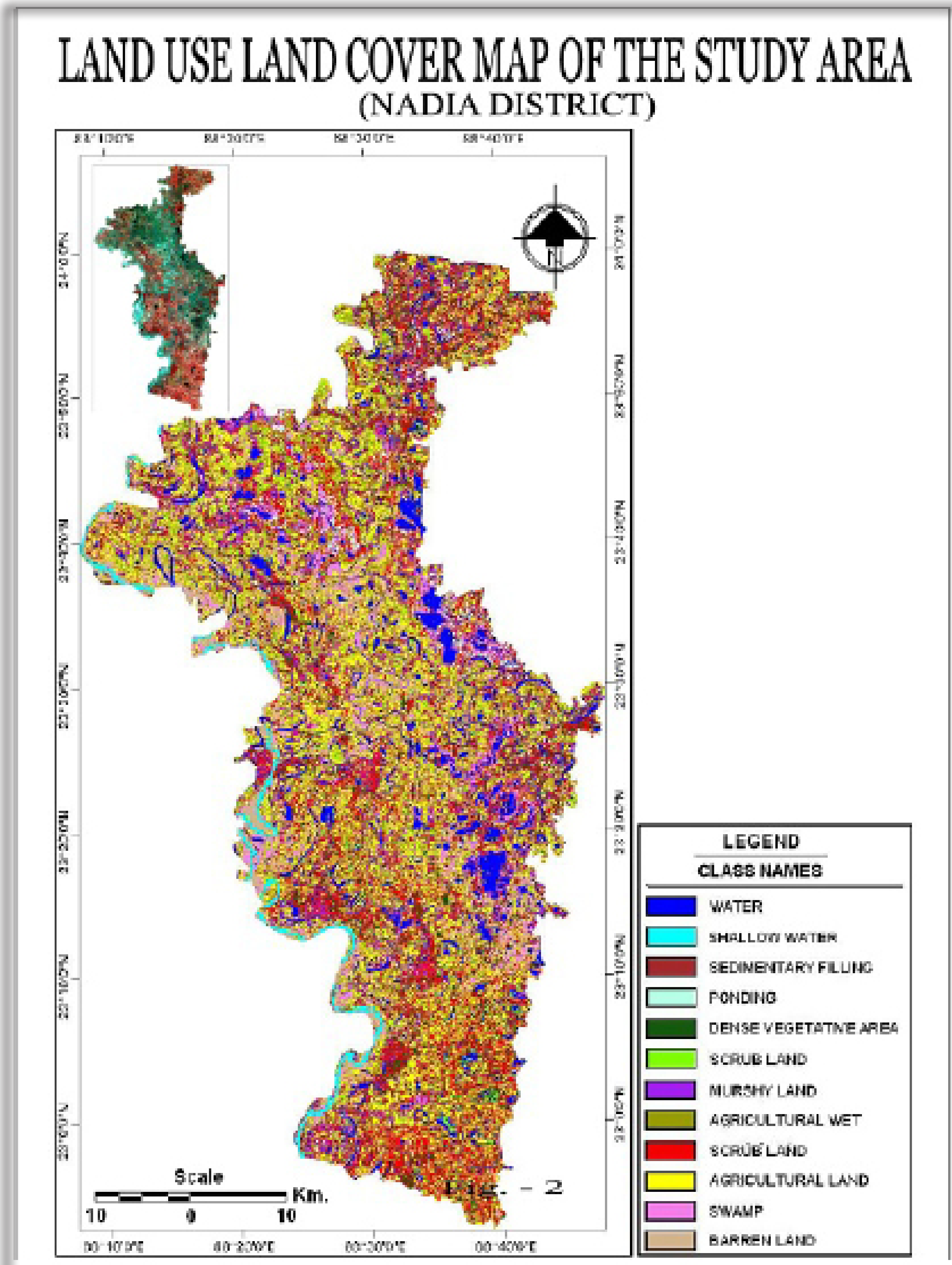

Fig. 2: Land use and Land cover Map of Nadia Dist.

SURFACE WATER CONDITION BASED ON FCC - 2000

NADIA DISTRICT (WEST BENGAL)

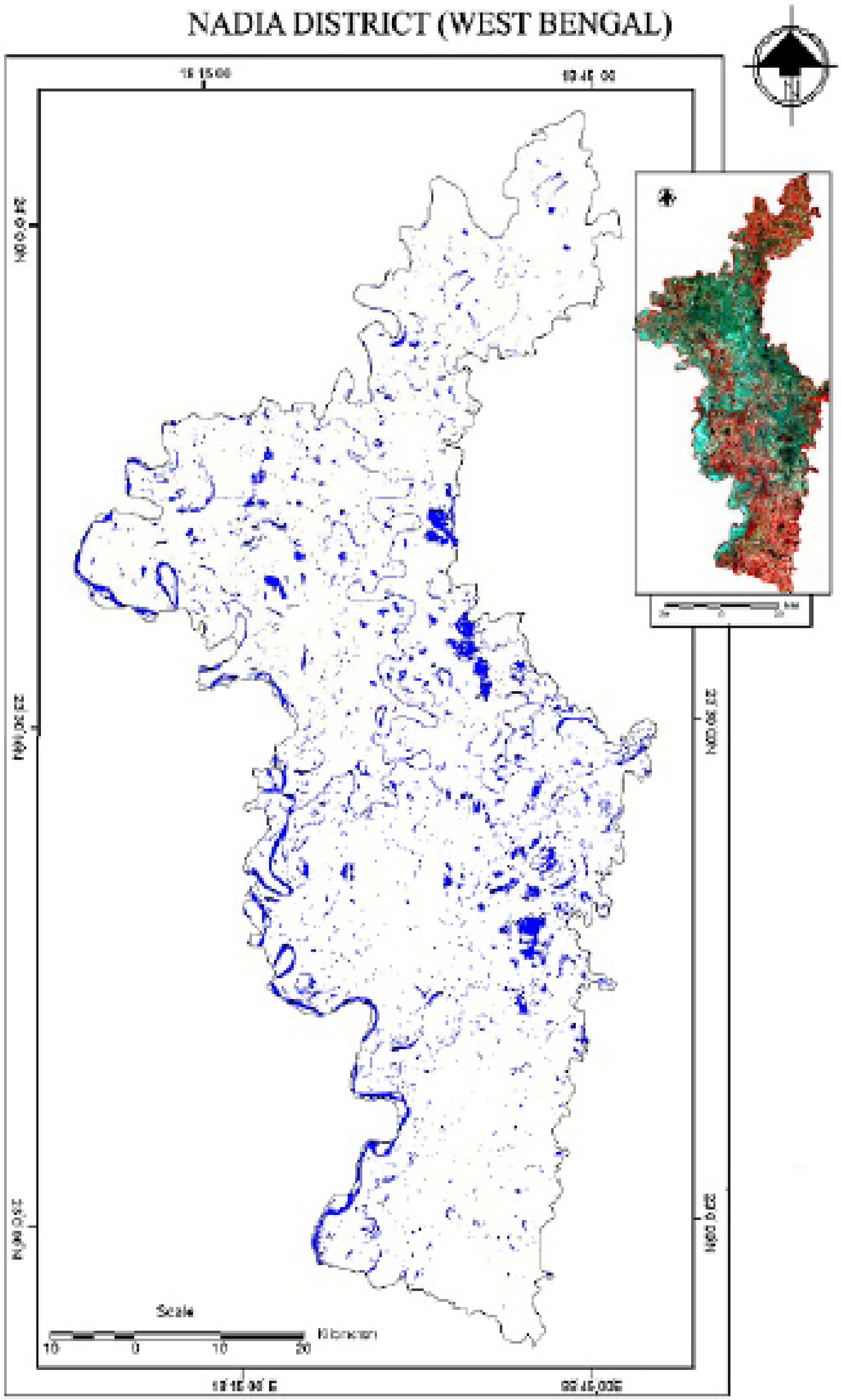

Fig. - 3

SOURCE : IRS . 1D . LISS III, 1990

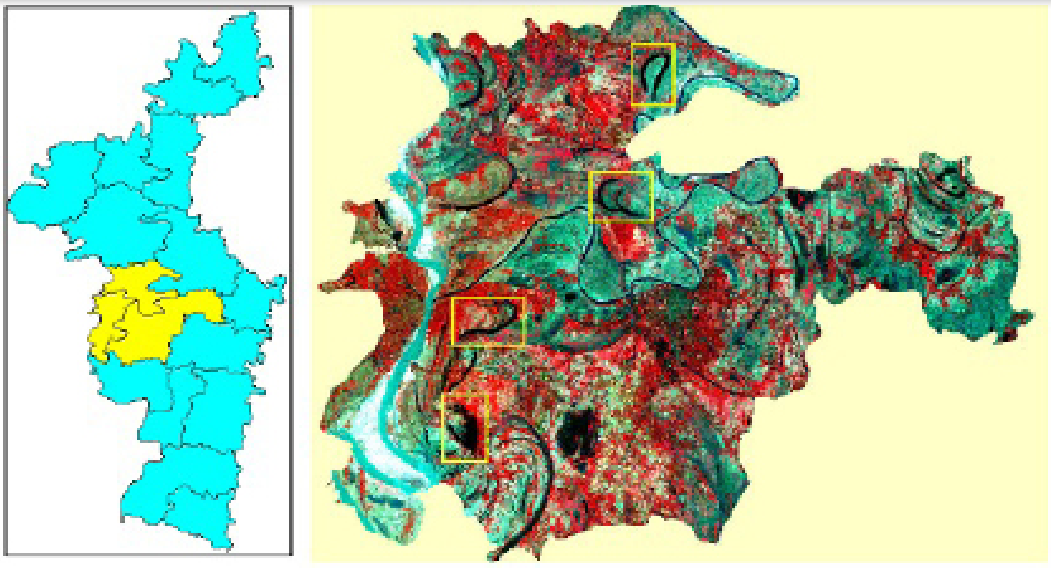

Fig. -4 :The four selected bil which is used for the study

Fig.4: The four selected bils of Nadia Dist. Used in study

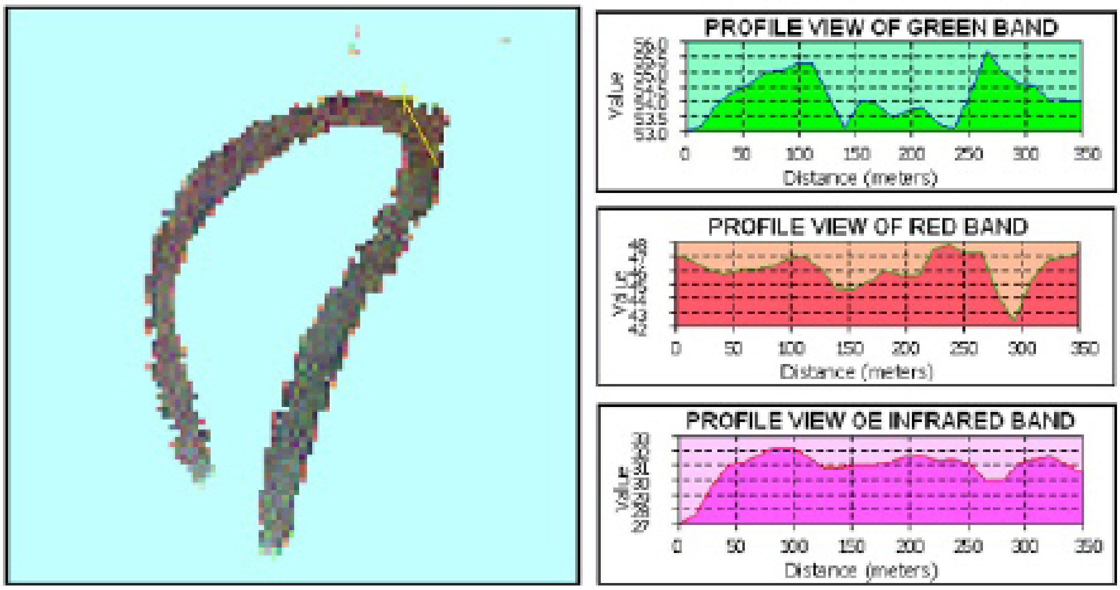

Fig. 5: Profile view of Noapara bil

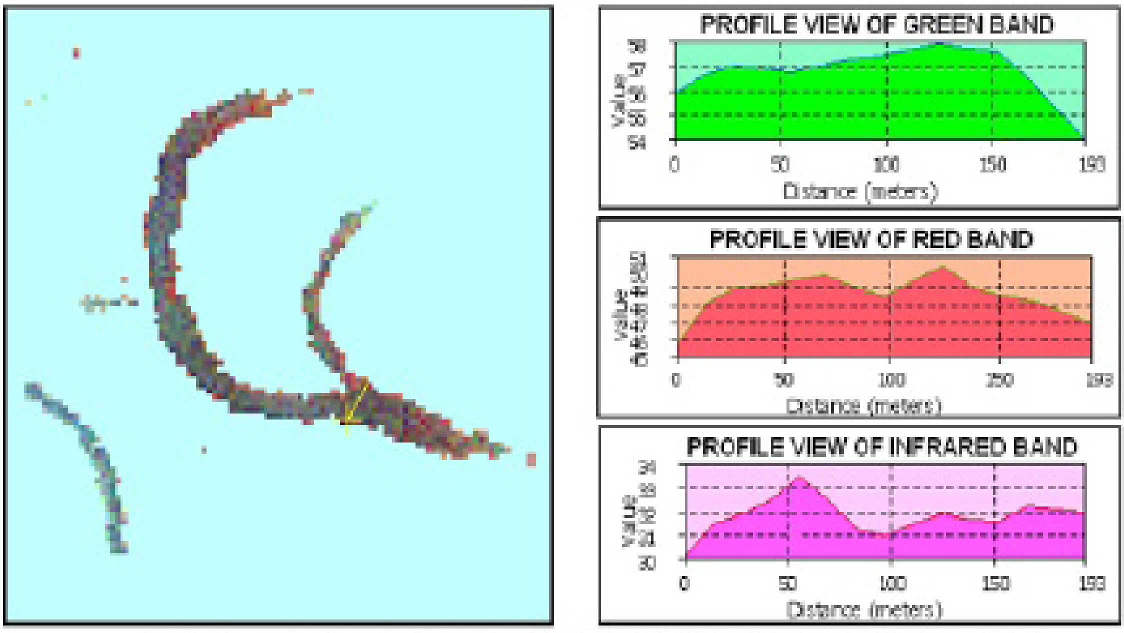

Fig.- 6 : Profile view of Hansadanga bil

Fig.6: profile view of Hansadanga bil

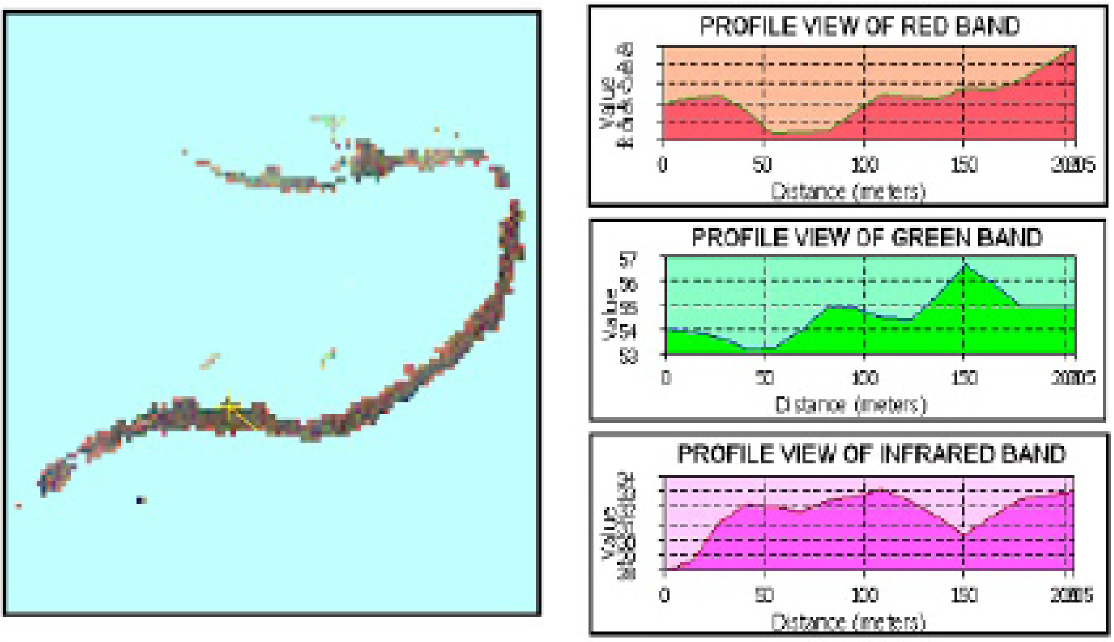

Fig.- 7 : Profile view of Alokananda bil

Fig.7: profile view of Alokananda bil

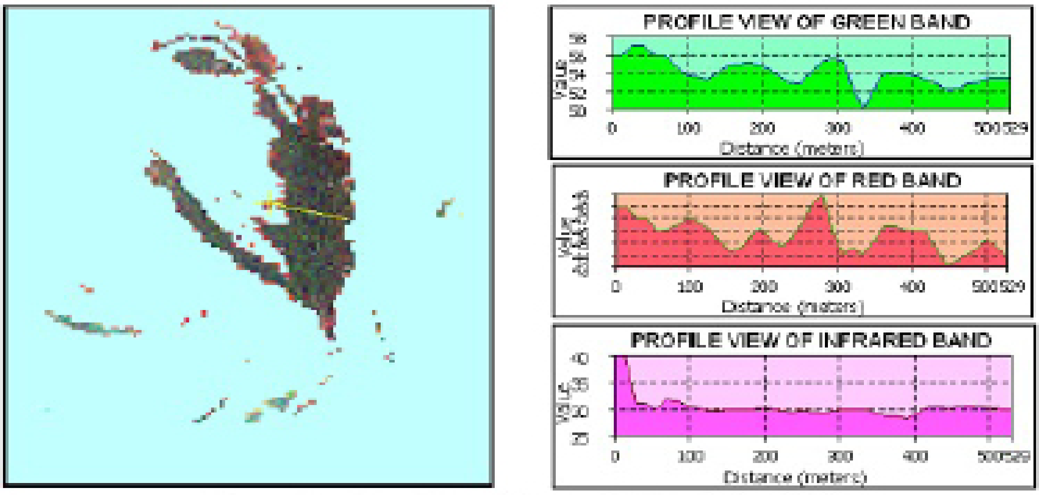

Fig.- 8 : Profile view of Bhaluka bil

Fig.8: profile view of Bhaluka bil

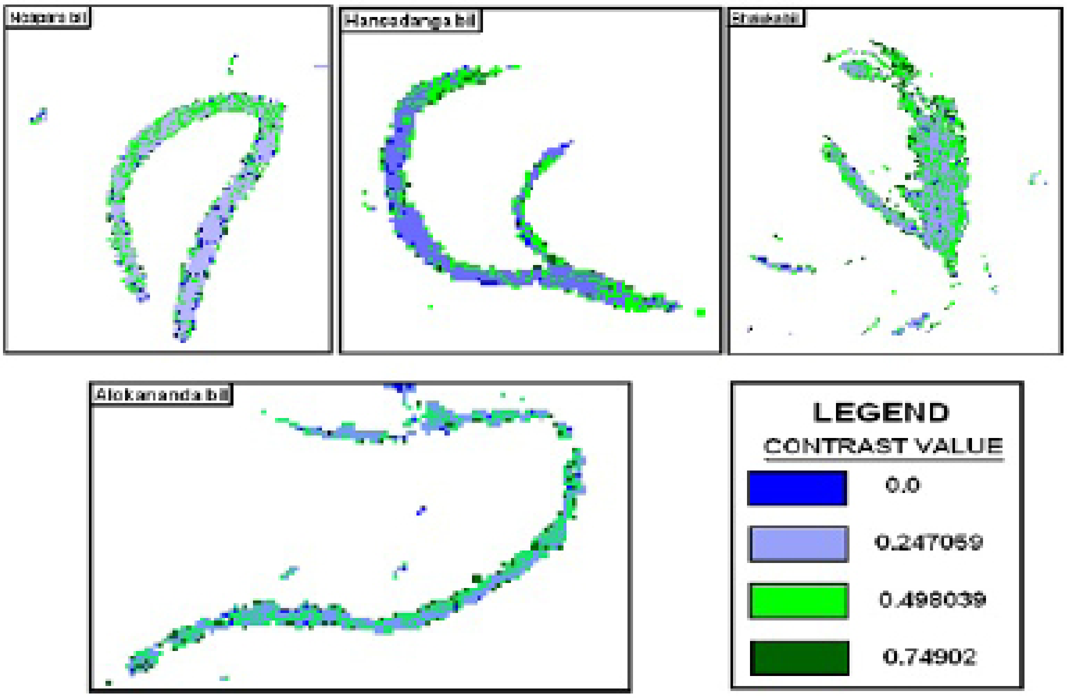

Fig. 9 : NDVI technique is applied on the FCCs of four bils and showing the contrast value

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Identification Of Service Facilities Of Urban Centres In Theni District, Tamilnadu: A Geospatial Analysis

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Abstract

Increasing population and demand for appropriate service and infrastructural facilities are posing serious challenges for the administrators and planners, and this is more so in urban areas which have been witnessing rapid population growth and urban sprawl in the last a few decades. With rapid urbanization, urban settlements emerge in different sizes; larger towns grow quite rapidly; and size defines the number, character and complexity of urban functions. They with their rapid growth record phenomenal changes in their physical and socio-economic domains. The spatial pattern of urban functions in a city reflects the status and significance of varied socio-cultural and demographic structure of urban population. The present study attempts to looks into the issues of service facilities of urban centres in Theni district, Tamil Nadu in the context of regional development from geospatial perspectives. It is to be noted that it is a study of small and medium towns. Small and medium towns help the population to easily access the needed services, thereby reducing the pressure on the larger towns. Theni district is an inland one in southern Tamil Nadu, and towns here belong to the categories of Class II to Class V. They normally provide functions of health, education and recreation. Methodology of simple statistics is followed for the required analysis in the study. Mapping and spatial analysis for the present exercise are carried out with the help of ArcGIS 9.3 and ERDAS Imagine 8.7.

Key Words: Urban, Geospatial, Facilities and Theni.

Pages: 9	References: 11

INTRODUCTION

Human activity brings modification to various parts of the earth surface with the passage of time. The magnitude of this modification is greater in the case of urban centres. Even here the nature of modification is different from one city to the other. The significance of an urban centre depends upon the number and status of services offered by it. Smaller urban centres provide limited number of services.

On the other hand, large metropolitan cities perform a variety of urban functions. These functions decide the role of the urban centre in the regional setting.

The 21st century witnessed a rapid shift of population from rural to urban areas in most of the countries of the world. Tamil Nadu is one of the most urbanized states in India. About 43.8 % of the total population in Tamil Nadu live in urban centres in 2001. The number of urban centres increased from 133 in 1901 to 474 in 1991 and 791 in 2001. The study of basic service facilities is essential to any human development.

Geospatial technologies play a key role in generating timely and reliable information for planning and decision making at all the levels from macro to micro. It is widely recognized that GIS is a modern technological tool to analyse both spatial and non-spatial data including temporal aspects in a cost-effective and efficacious manner. Keeping this in mind an attempt has been made to identify and analyse the service facilities in the district.

STUDY AREA

Theni is one of the Southern districts of Tamil Nadu State and it is bounded on the north by Dindigul district, on the east by Madurai district, on the south by portions of Virudhunagar district and Idukki district of Kerala State and on the west by Idukki (Kerala). The district administrative headquarters of Theni district is situated at Theni - Allinagaram town.

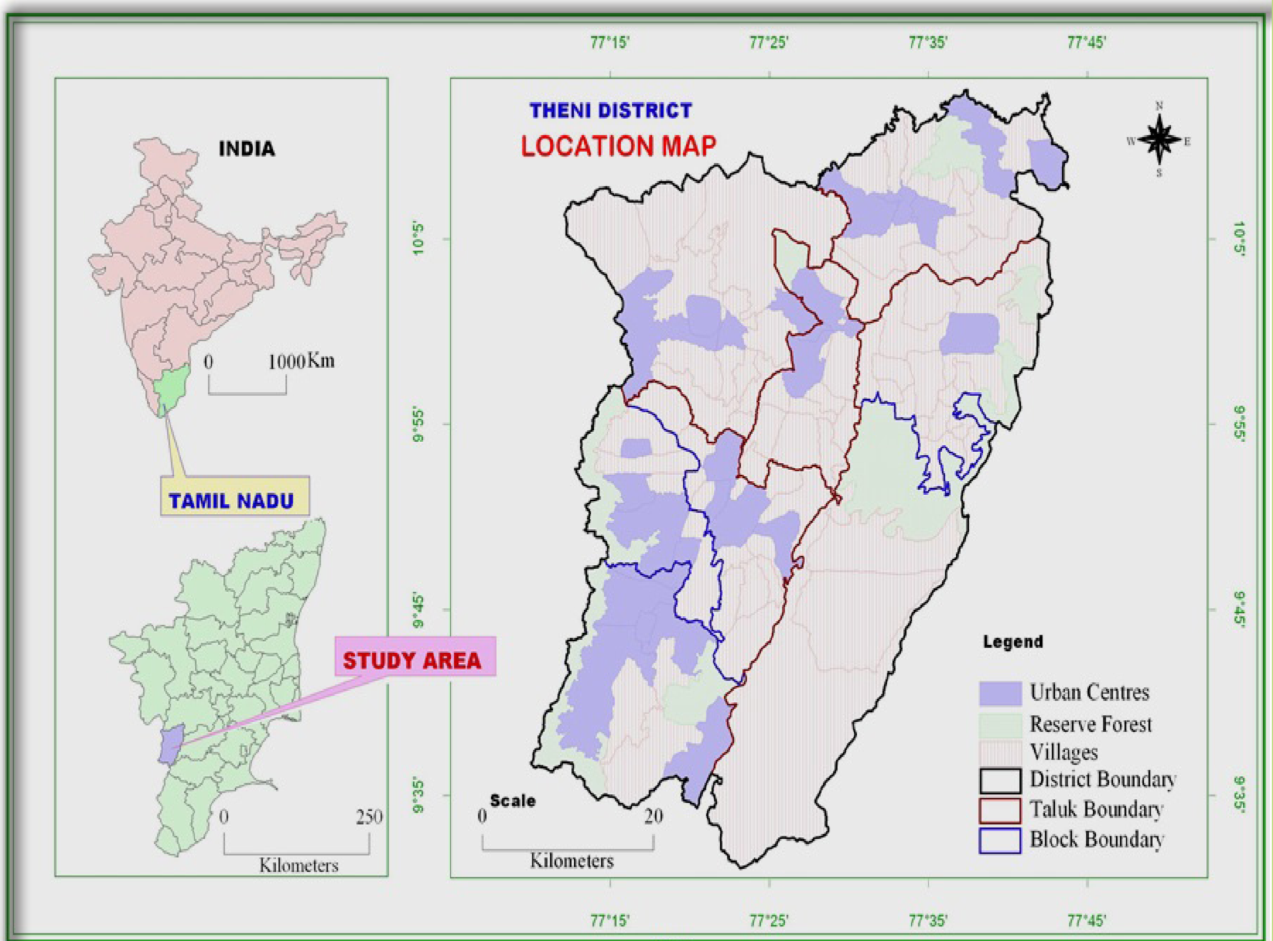


Fig:1

The district lies between 9° 30’ North latitude to 10° 15’ North latitude and 77° 10’ East longitude to 77° 45’ East longitude. The topography of the district is mostly hilly. Vaigai, Suruli, Varahanadi Kotta Kudi, Varattaru and Manjalar rivers are flowing in Theni district. Periyar, Vaigai, Manjalar and Sothuparai dams are extensively used for agricultural and drinking purposes. The district comprises of two Revenue Divisions viz., Periyakulam and Uthamapalayam, and Five Revenue Taluks, viz., **1**.Theni, **2**.Periyakulam, **3**.Andipatti, **4**.Uthamapalayam and **5**.Bodinaickanur. There are eight Community Development (CD) blocks. Theni district has 26 urban centres in 1991 and 28 urban centres in the year 2001.

OBJECTIVES

The following are the major aims and objectives of the present study.

* To study the spatial dimension of selected service facilities in Theni District urban centres

* To identify the nature of relationship between demographic characters and service facilities in Theni District urban centres

* To identify the relative importance of services within Theni District urban centres

Data Base

For the present study, the following data base and techniques are used:
Survey of India Toposheets with 1: 50,000 scale.
Topo sheet numbers: 58 F/4, 58F/8, 58 F/12, 58 G/1, 58G/2, 58G/5, 58G/6, 58G/9 and 58 G/10.
Primary Census Abstract Tamil Nadu 2001
Relevant literatures

Software Used

Arc GIS 9.3
ERDAS Imagine 8.7
Arc View 3.2a

RESULTS AND DISCUSSION

Service Facilities

The spatial pattern of service facilities in a place reflects the status and significance of varied socio-cultural and demographic aspects in the study area. Theni is an important southern district in Tamilnadu state. It is also a commercial and agricultural area. Taking this as the basis as well as the availability of data, the following service facilities are taken for spatial analysis. A total of three major groups are considered. They are:

1. Health Facilities
2. Educational Facilities and
3. Recreational Facilities

To assess the status of these services a ratio is taken between the total population and the number of functional service units in the urban centres. Table 1 provides the availability of these service functions in the study area. The study area has 28 urban Centres of which seven are coming under Class V, another thirteen under Class IV, Five under Class III and Three under Class II category. The present study has considered the service facilities of urban centres in Theni district.

MEDICAL FACILITIES

Health is very essential to all humans. India has a vast network of public and private health services manned by a large number of medical and paramedical personnel. Health service facilities include government hospitals, private hospitals, medical shops, clinical services, blood bank, laboratory, etc. Upkeep of good health was always given priority by civilized man. He has been making tremendous efforts to overcome illness and was successful in combating dreaded diseases. It may be noted that the study area has a comparatively better service function and has at least one hospital/clinic for every 1500 people or less. They are mostly found in Andipatti (Class III), Melachokkanathapuram (Class IV) Odaipatti (Class IV), Kombai (Class IV) and Highways Township (Class V) of the study area (Figure.2). Genguvarpatti, B.Meenakshipuram, Chinnamanur and Kambam urban centres have low health service function while Other urban centres have one health unit for more than 1500 people with moderate concentration of this service function. Boothipuram urban centre do not have this service.

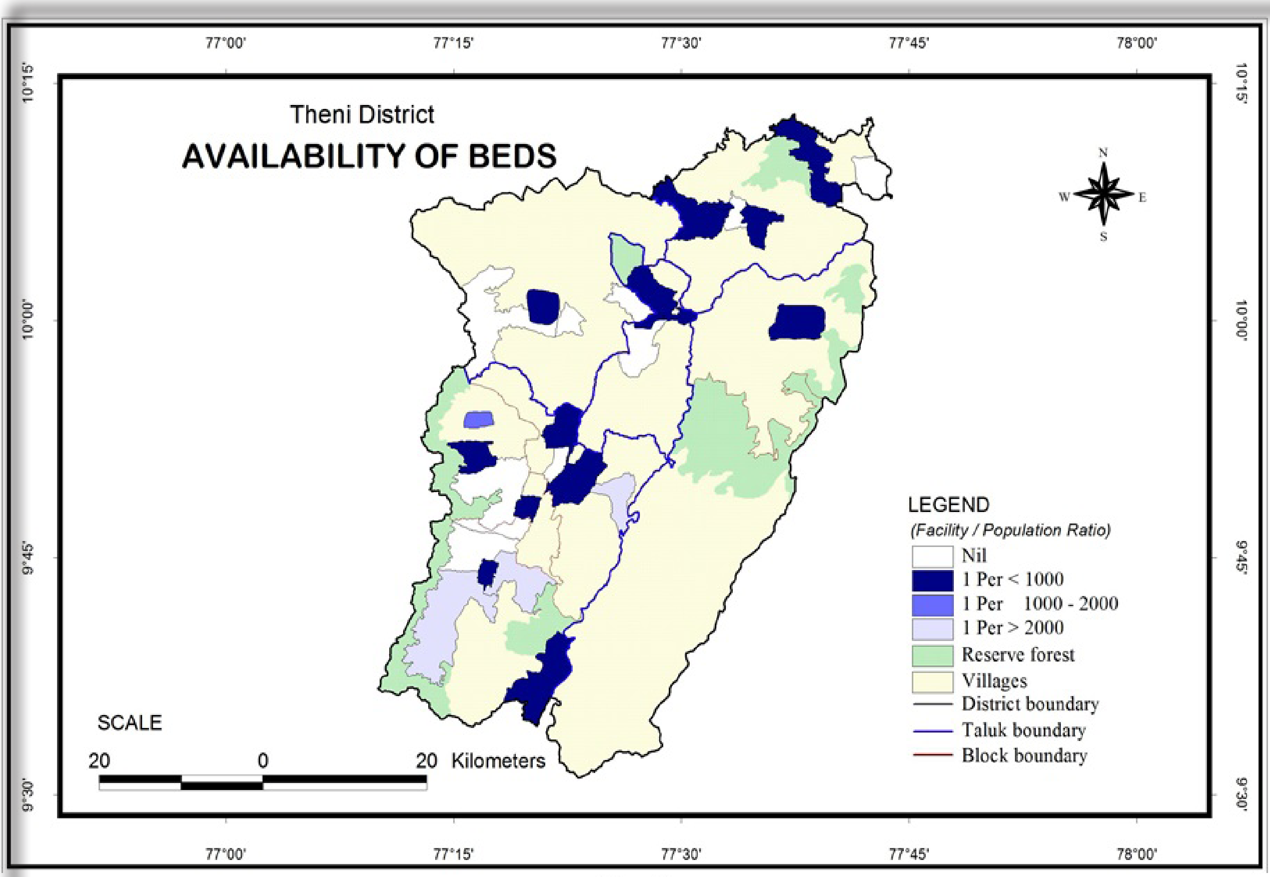


Fig: 3

Altogether a total of 1361 beds are available in the various categories of hospitals in Theni urban centres. Nearly one half of the urban centres have better service in this facility. Maximum number of beds are found in Periyakulam, Theni, Andipatti - Jakkampatti and Bodinayakkanur (Figure.4). These urban centres have more than 100 beds in this service. Thevaram town has medium service in this function. Gudalur, Kamayagoundanpatti and Odaipatti towns have least service, that is more than 2000 people have one bed (Figure.3). Other urban centres do not have this service.

EDUCATIONAL FACILITIES

Education means gaining the knowledge and learning new skills. The level of education is versatile indicator of the regional development. The importance of education and its spread cannot be exaggerated in the case of developing countries like India. It is one of the prime concerns of the government. Education in its broadest sense is any act or experience that has a formative effect on the mind, character or physical ability of an individual. Education is given at various levels such as school, college and professional levels.

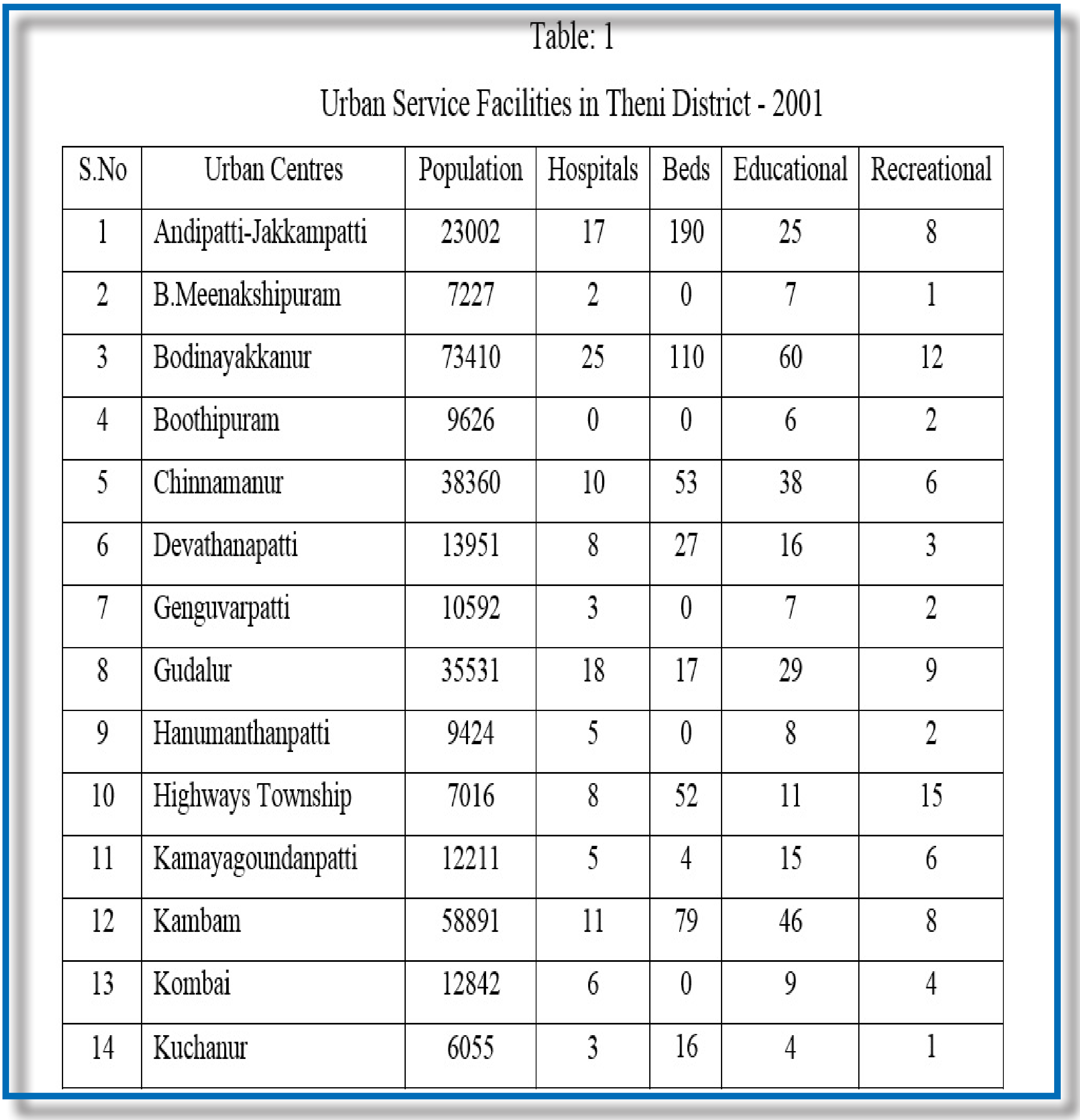
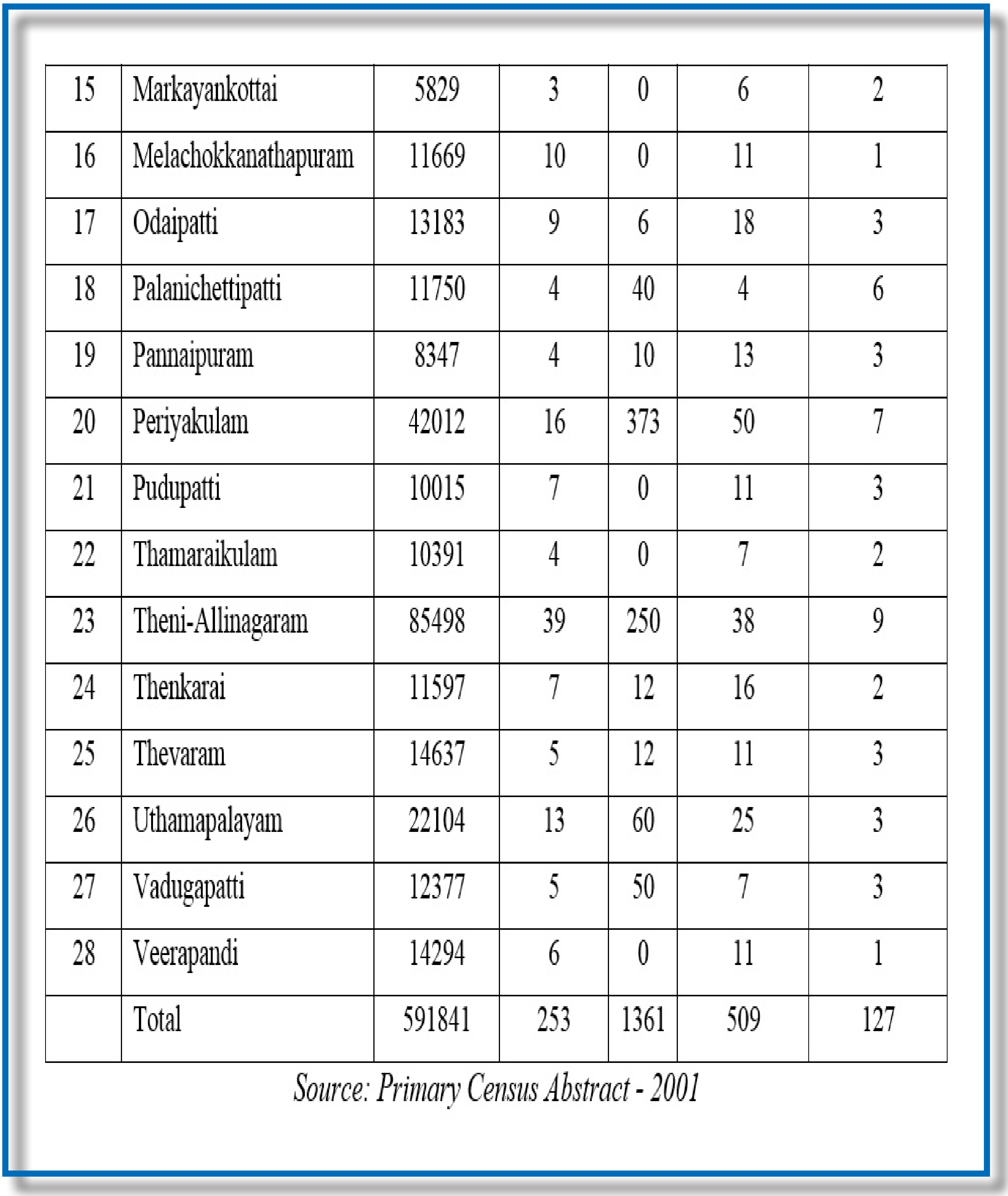


Table: 1

Urban Service Facilities in Theni District - 2001

S.No	Urban Centres	Population	Hospitals	Beds	Educational	Recreational
1	Andipatti-Jakkampatti	23002	17	190	25	8
2	B.Meenakshipuram	7227	2	0	7	1
3	Bodinayakkanur	73410	25	110	60	12
4	Boothipuram	9626	0	0	6	2
5	Chinnamanur	38360	10	53	38	6
6	Devathanapatti	13951	8	27	16	3
7	Genguvarpatti	10592	3	0	7	2
8	Gudalur	35531	18	17	29	9
9	Hanumanthanpatti	9424	5	0	8	2
10	Highways Township	7016	8	52	11	15
11	Kamayagoundanpatti	12211	5	4	15	6
12	Kambam	58891	11	79	46	8
13	Kombai	12842	6	0	9	4
14	Kuchanur	6055	3	16	4	1



15	Markayankottai	5829	3	0	6	2
16	Melachokkanathapuram	11669	10	0	11	1
17	Odaipatti	13183	9	6	18	3
18	Palanichettipatti	11750	4	40	4	6
19	Pannaipuram	8347	4	10	13	3
20	Periyakulam	42012	16	373	50	7
21	Pudupatti	10015	7	0	11	3
22	Thamaraikulam	10391	4	0	7	2
23	Theni-Allinagaram	85498	39	250	38	9
24	Thenkarai	11597	7	12	16	2
25	Thevaram	14637	5	12	11	3
26	Uthamapalayam	22104	13	60	25	3
27	Vadugapatti	12377	5	50	7	3
28	Veerapandi	14294	6	0	11	1
	Total	591841	253	1361	509	127

Source: Primary Census Abstract - 2001

Devathanapatti, Periyakulam, Thenkarai, Palanichettipatti, Highways Township, Uthamapalayam, Odaipatti, Kamayagoundanpatti, Pudupatti, Pannaipuram and Markayankottai urbans have a comparatively higher level of this service function. Here one institution is available for every 1000 people. Genguvarpatti, Vadugapatti, Andipatti, Theni-Allinagaram, Boothipuram and Kuchanur towns are least served in this category. Other urban centres have a moderate service in this function as clearly shown in figure.4.

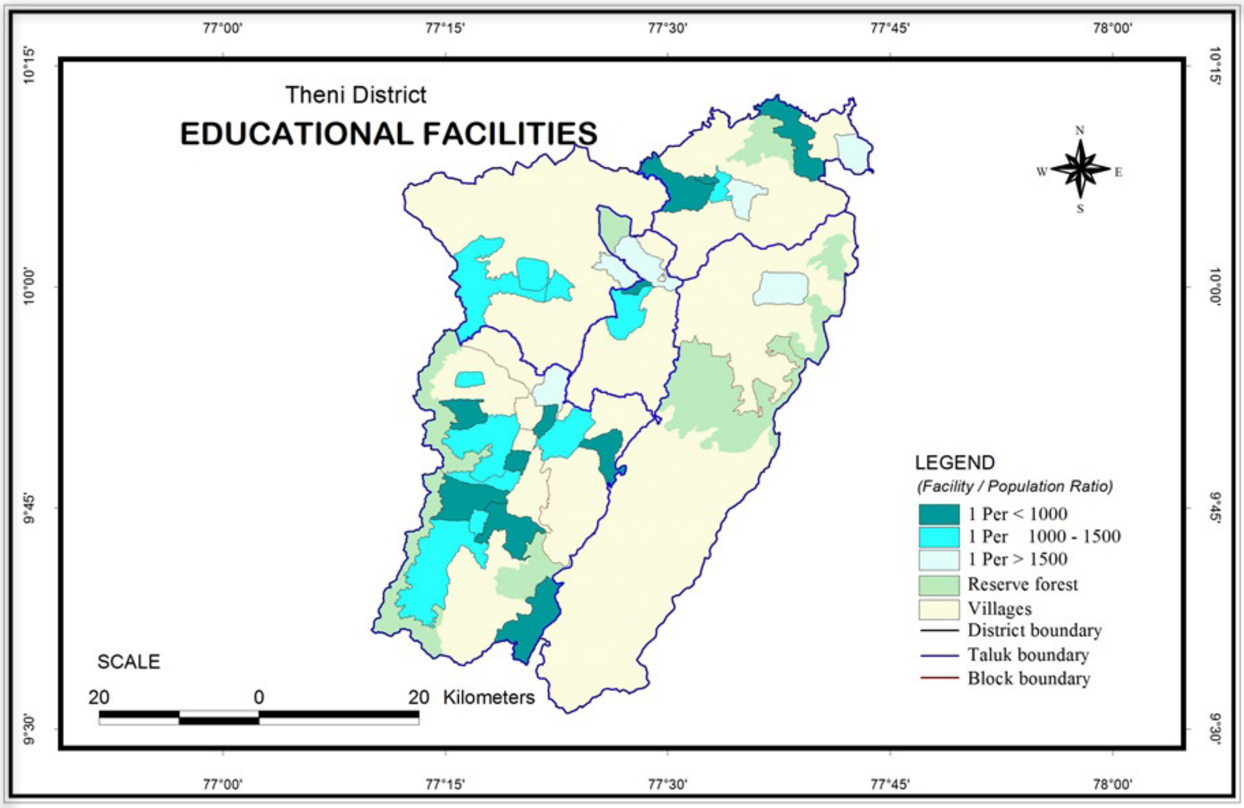


Fig: 4

RECREATIONAL FACILITIES

Recreational facilities are very enormous in urban areas than in rural areas. Cinema theatres, Parks, Library, reading Rooms and Community halls are considered under this category. Uthamapalayam taluk have higher concentration of this service facility. Gudalur, Highways Township, Odaipatti, Thevaram, Kombai, Kamayagoundanpatti, Boothipuram, Palanichettipatti, Vadugapatti, Devathanapatti, Andipatti – Jakkampatti, Pudupatti and Markayankottai are comparatively better served while Melachokkanathapuram, and Theni - Allinagaram urban centers are least served. Other urbans have moderate service in this function. Figure.5 shows the distribution of recreational facilities in Theni district.

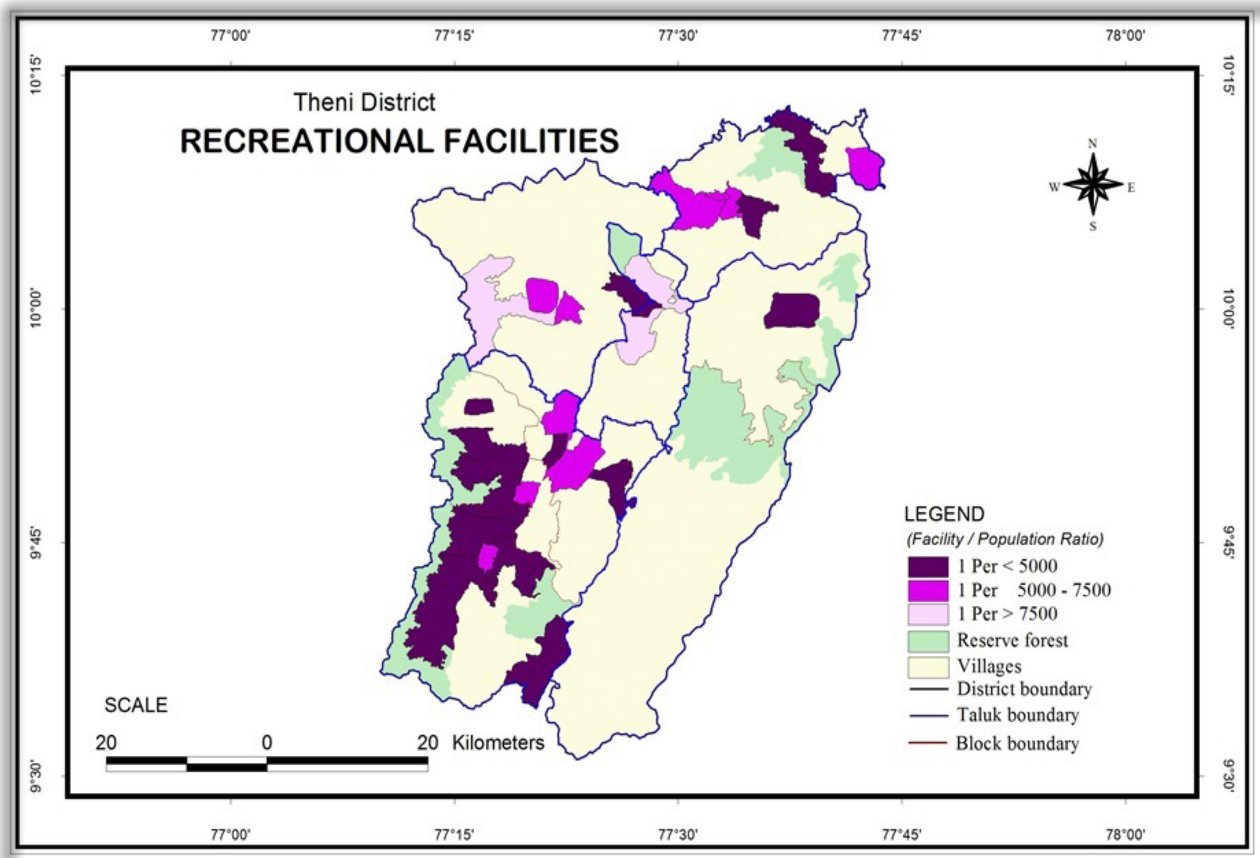


Fig: 5

CONCLUSION

To conclude the following are the salient inferences made from the study:

* Class II urban Centres (Theni - Allinagaram, Kambam and Bodinayakkanur) have availability of beds is high then other facilities

* Theni - Allinagaram and Bodinayakkanur (Class II) urban centres have moderate service in educational and recreational facilities.

* Though Kambam is the major urban centre (Class II) it is having a poor service in terms of ratio to the number of peoples in hospital services.

* There is no hospital service and availability of beds in Boothipuram (ClassV) urban centre, but recreational service high.

* Some Class IV and Class V urban centres not have availability of beds.

* Highways Township urban centre (Class V) has better served in most of the service functions considered.

* Class IV urban centres have better facilities compare then other service facilities.

* Andipatti urban centre (Class III) also have good service except in educational service.

* Other urban centres have moderate level of the selected services.

A temporal study can also be undertaken to find out the improvement of status of various urban centres with regard to the service facilities for future development planning.

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Integrated Geospatial Technologies for Soil Salinity Assessment (A case study of south 24 pargana Dist., West Bengal, India)

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Abstract

Šalinity is the parameter analyzing the soil condition through the accumulation of the salt over the land or soil by natural process like water table fluctuation and transporting of salt to the ground through capillary action, water logging or by human induced process of landuse practice and over fertilization over the land. This study accounts for identification and mapping of salinity zone over the Basanti, Gosaba Island (808.314sq. km) of South 24 Pargana District of West Bengal through analysis of Remote Sensing and GIS Technique. The parameters like pH (<8.2, IS),Electrical Conductivity(EC) and Sodium Absorption Ratio (SAR) were derived by ground sampling of soil over the study area along with GPS positions.The collected samples were tested in laboratory method and later were checked with the with Remote Sensing based Indices analysis over the satellite images over 1975,2000, 2010 to find out the changes in the due to over salinization. The Weighted overlay Analysis procedure were followed to assign the weighted according to the importance of parameters taken into account for salinity zone identification and mapping to produce zones of higher, moderate, lower salinity zones over the study area.

Key Words: Basanti & Gosaba Island, pH, EC, SAR of soil , Indices Analysis ,Weighted Overlay and Salinity Zonation.

Pages: 45 References: 10

INTRODUCTION

Salt-affected soils are caused by excess accumulation of salts, typically most pronounced at the soil surface. Salts can be transported to the soil surface by capillary transport from a salt laden water table and then accumulate due to evaporation. They can also be concentrated in soils due to human activity, for example the use of potassium as fertilizer, which can form sylvite, a naturally occurring salt. As soil salinity increases, salt effects can result in degradation of soils and vegetation.

Salinization is a process and results from:

- High levels of salt in the soils.
- Landscape features that allow salts to become mobile (movement of water

table).

- Climatic trends that favor accumulation.
- Human activities such as land clearing activities.

Remote Sensing is an effective science and technology to detect the salinity over the land by its Indices Based application and which intern reduces the conventional method of ground surveying and measurement. The application of two major indices like Normalized Difference Vegetation Index, Salinity Index with wavelength reflectance of soil in electromagnetic spectrum and calculation process the salinity can be measured by assessing vegetation health and soil over the study area. But in the research method the main parameters like soil pH, Electrical Conductivity (ds/m),Sodium Absorption Ratio of soil has to be considered. The ground truth verification of prime requirement (though time,cost increasing) by sampling and checking the indices analysis through remote sensing. GIS also plays a pivotal role in overlay analysis and decision making with integration of remote sensing technology.

PURPOSE AND SCOPE

- Salt – affected soils are widespread over the world especially in arid, semi arid and some sub- humid regions. Soil salinity has been brought about by natural or human- induced processes and is a major environmental hazard. Crop growth reduction due to salinity is generally related to the soil in osmotic potential of the root zone.
- Recent advances in remote sensing technology have opened new vistas in inventory, characterization and monitoring of degraded lands. Remote sensing and GIS have been effectively used to study the dynamic behavior of salinity and water logging.

- Satellite imagery and false colour composites are visually interpreted to identify salt affected lands and locate their geographic position using the Global positioning system. Remote sensing and GIS software are utilized to analyze digital remote sensing data for the preparation of a digital database on salinization and the effect on cereal crops.
- In general remote sensing data can be used as a tool for discriminating between saline soils and non-saline soils on the dark soils that have high clay content but not with soils that have high sand content. The low soil salinity and early stages of salinization lower than 4 dS/m, is hard to be detected on bare soil using remote sensing.
- The use of Indices like salinity index and NDVI are the most challenging aspects of Remote Sensing Technology and analysis through weightage overlay also accounts for depending on other parameters on importance basis for spatial decision making in salinity zonation over any area.
- In classical technique researches on salinity were mainly based on the field sampling method and based on Soil pH, Electrical Conductivity, Sodium absorption ratio. It was hard to analyze and predict without salinity and required long time and economy.
- Remote Sensing and GIS technology with the integration of Field Surveying can be proved as the optimal decision making process for salinity zone identification and Zonation and will save time, money, energy of the research work.
- On this basis faster decision can

be obtain to propose policy or method to conserve the land of any area which is under continuous process of salinization.

LITERATURE REVIEW

N.Katerji *et.al,* 1989 indicates Remote sensing technology is a useful tool in obtaining information with respect to soil characteristic sand land degradation aspects. This work considers the possibilities of using band ratios (plant cover and soil indices) for classification of saline lands in a part of Neyshabor plain region in Khorasan Razavi State in which ETM land satellite data of July 10 2002 was also used. Satellite images were reviewed and due to primary and radiometric corrections, the study area was selected from complete frame image. A Selection of sampling points with uniform distributions was performed and soil samples from 0 -10 cm of the studied point were collected and their geographical positions were recorded by GPS. 39 soil samples were analyzed for EC, pH, soluble Ca, Mg, Na, Cl, CO_3, HCO_3, SO_4 ions. The position of samples was determined on each image, and Digital Number (DN) in each point was detected. Results indicated that the regression coefficients obtained for main and composite bands were very low, but revealing that the use of composite bands (plant cover indices) compared to main bands resulted to an increasing in the regression coefficient in the equations. In addition, when statistical analysis is limited to Data of higher EC, regression coefficients increase compared to when total sample parameters was statistically analyzed. All in all, it was realized that, due to very low regression coefficients among numerical vales obtained from main bands and plant indices and EC of soils, the classification of satellite images on the bases of a suitable regression model is not possible and also these coefficients for classification of the images are not sufficient.

Mohammed Saifeldeen Abd-Elwahed ,2005, aimed at addressing the capability of using remote sensing data in detecting and tracking soil salinization variability using a series of experimental methodologies. In a controlled experiment, the spectral reflectance changes associated with salt crustformation on soil surfaces were tracked in order to detect the optimum moisture levels for salinity detection and recognize the influence of soil texture on salinity-induced spectral changes. In another experiment, lettuce plants were utilized to assess plant biophysical responses to moderate salinity levels with canopy-level reflectance data. An FR-ASD spectrometer was used to collect reflectance data in the 400-2500 nm spectral region. Finally, MODIS satellite data were employed to analyze the temporal profiles of selected high (8-11 dS/m), moderate (4-6 dS/m) and none (1-3 dS/m), salt affected sites in the Nile Delta, Egypt. The analyses of spectral data revealed that the use of remote sensing data to discriminate salinity levels in soils is highly affected by moisture content and texture. At low moisture contents, salts have high reflectance in the VIS-NIR spectral region but low reflectance in SWIR region. Spectral ambiguity with soil salinity was found across soil texture types. Significant relationships were found between plant chlorophyll content and the REP index (R_2 =0.97), and dry biomass with SAVI values (R_2 =0.94) under different salinity treatments. The spectral

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vegetation indices (VI's), SAVI and REP, and water indices (WI's) were found to be effective in discriminating between plants growing under moderate conditions of soil salinity and a non-saline condition. The combination between VI's and WI's was found to be useful in improving the abilityto assess salinity stressed plants from non-stressed plants. Finally, MODIS results showed separability between canopy seasonal growth under high saline (HS) and non-saline (NS) conditions based on phenology. Canopies growing under HS conditions had lower VI and WI values in the green-up period. It may be concluded that using plant biophysical response to detect soil salinity could be useful in detecting early stages of salinity. Also using the combination between VI's and WI's using MODIS data is a useful to discern between high saline and none saline areas.

Astaraei *et. al.*,2009 conducted studies on evaluations of vegetation cover and soil indices for saline land classification in neyshabour region using ETM$^+$ landsat image. Remote sensing technology is a useful tool in obtaining information with respect to soil characteristics and land degradation aspects. This work considers the possibilities of using band ratios (plant cover and soil indices) for classification of saline lands in a part of Neyshabor plain region in Khorasan Razavi State in which ETM land satellite data of July 10 2002 was also used. Satellite images were reviewed and due to primary andradiometric corrections, the study area was selected from complete frame image. A Selection of sampling points with uniform distributions was performed and soil samples from 0 -10 cm of the studied point were collected and their geographical positions were recorded by GPS. 39 soil samples were analyzed for EC, pH, soluble Ca, Mg, Na, Cl, CO_3, HCO_3, SO_4 ions. The position of samples was determined on each image, and Digital Number (DN) in each point was detected. Results indicated that the regression coefficients obtained for main and composite bands were very low, but revealing that the use of composite bands (plant cover indices) compared to main bands resulted to an increasing in the regression coefficient in the equations. In addition, when statistical analysis is limited to Data of higher EC, regression coefficients increase compared to when total sample parameters was statistically analyzed. All in all, it was realized that, due to very low regression coefficients among numerical vales obtained from main bands and plant indices and EC of soils, the classification of satellite images on the bases of a suitable regression model is not possible and also these coefficients for classification of the images are not sufficient.

Stephan Liersch *et. al.*,2008, describes Environmental resources management requires adequate tools to deal with various types of data. Due to the different characteristics of environmental data it is necessary to use appropriate tools to administer the data according to their nature. An Advanced Monitoring and Information System (AMIS) is proposed here that is able to integrate data provided by different sources in order to produce targeted information. The AMIS is an open source software tool consisting of three main components. A GIS, acting as user interface, provides functions to visualize and analyze spatial data.

An object-relational database management system is used to administer data in various formats. To exchange data between GIS and database an interface was implemented in the GIS. The application of the AMIS is presented on the basis of two different case studies. In the first case study we demonstrate the capabilities of the AMIS in supporting soil salinity assessment and monitoring by integrating local knowledge as alternative source of information in a data-poor region. In the second case study the development of a rainfall-runoff database to support flood risk management is described. Therefore, a rainfall generator and a hydrological model were implemented in the system. decreased except for low lying areas with poor drainage where salinity was still relatively high or fluctuated depending on the season.Lack of familiarity with the salinity problem led to crops being planted in soil too saline for plant growth, or being watered with saline groundwater, leading to failed crops, wasted time, money and seed, and creating despondency among farmers already traumatised by the tsunami.Timely assessments of salinity help farmers avoid growing crops in saline areas and indicate when management practices are needed to alleviate salinity.

Bloem *et. al.,* 2009 ,conducted a study on general identification of the threat and areas at risk derived from existing data. Subsequently, within the delineated zones, specific locations with high salinity risks have to be identified. Generally, three types of approaches exist to identify areas at risk (Eckelmann *et. al.,* 2006): 1. Qualitative approach, using expert knowledge to evaluate important processes,formulate criteria and discover (local) areas at risk. 2. Quantitative approach, based on measured data, providing relative comparisons regarding baselines and thresholds. 3. Model approach, using models to predict the extent of soil degradation, taking local conditions into account. This approach enables assessment of trends by scenario analysis.

Indonesian Agency for Agricultural Research and Development, Indonesia NSW Department of Primary Industries, Australia,2009 generated report on This chapter covers the factors that influence soil salinity, methods for assessing salinity in the soil, recommendations for how to monitor soil salinity over time and management of farming in salinity- affected areas. Seawater inundation introduced salinity into areas where it had never before been a problem. As salts leached, surface salinity levels dropped faster than at depth. Rainfall soon leached salt from most sandy soils, but after seven months, clay soils inundated for one to three days after the tsunami had low to moderate salinity, and soils inundated for six days had higher salinity levels. In October 2005, 10 months after the tsunami, soil salinity was still a significant constraint to crop production during the dry season, with many farmers and extension workers reporting yield declines of around 50%. In January 2007 the salinity problem had substantially.

Avadhesh kumar koshal (2010) analyzed IRS 1D LISS III of March 2000 for indices. Vegetation indices were found to be sensitive to the influence of salinity on plant growth. In this study, three types of vegetation index Soil Adjusted Vegetation Index (SAVI), wetness index (WI) and soil brightness indices (SBI) were used to study crop condition influenced by salinity. The wetness index and soil brightness indices were applied to improve the interpretability of the image data. Classified SAVI image was very useful for identifying the normal crop and crop affected by severe salinity. The application of the Soil Brightness Index was found useful for identifying mainly salt affected lands. The spectral vegetation indices were found to be effective in discriminating between plants growing under salt affected conditions and a non-saline condition.

Abbas *et. al.,* 2010 described an integrated approach to assess the soil salinity using remotely sensed data. This encompasses spatial analysis of ground truth and satellite data. The study area is located in the District of Faisalabad in Pakistan. The ground truth data of soil salinity from selected sampling points is tied to the corresponding pixels from the satellite image bands Remotely sensed data based salinity indices (band combinations) and principal components using principal component analysis (PCA) are developed to find out the occurrence pattern of the salinization. Out of the six salinity indices developed, the following proved to be the most promising when compared with ground truth data.

Where B_1, B_2 and B_3 are bands of the satellite, IRS-1B LISS-II, in spectral range of band 1 (0.45-0.52 mm), band 2 (0.52-0.59 mm) and band 3 (0.62-0.68 mm) respectively. The resulting images were categorized into three distinct classes of saline soils; slightly saline,moderately saline and strongly saline. Using supervised maximum likelihood classification, the images were classified with an overall accuracy.

Majid Rashidi *et. al.,*2011 described that there were many instances in which it was desirable to determine relation between indices and soil salinity.For example, Sodium Absorption Ratio were often determined using laborious and time consuming lab testing method.But it is easier to use salinity index.In the study he has used linear regression model for predicting SAR,EC..The statistical study indicated that in order to predict soil Sar based on EC the linear regression model SAR = 1.91+ 0.68 EC R_2 = 0.69 can be recommended.

OBJECTIVE

- To test the Physio-Chemical properties of soil on different areas and determination of soil salinity based on pH, EC and SAR.

- To develop an approach that amalgamates remote sensing data with GIS techniques to determine the soil salinity zonation and Mapping.

METHODOLOGY

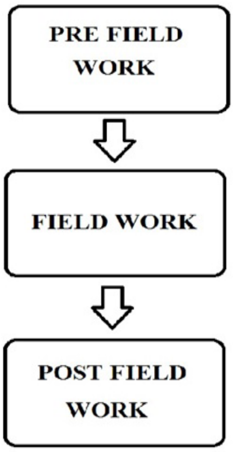


Fig.2.1 Basic Structure of Methodology

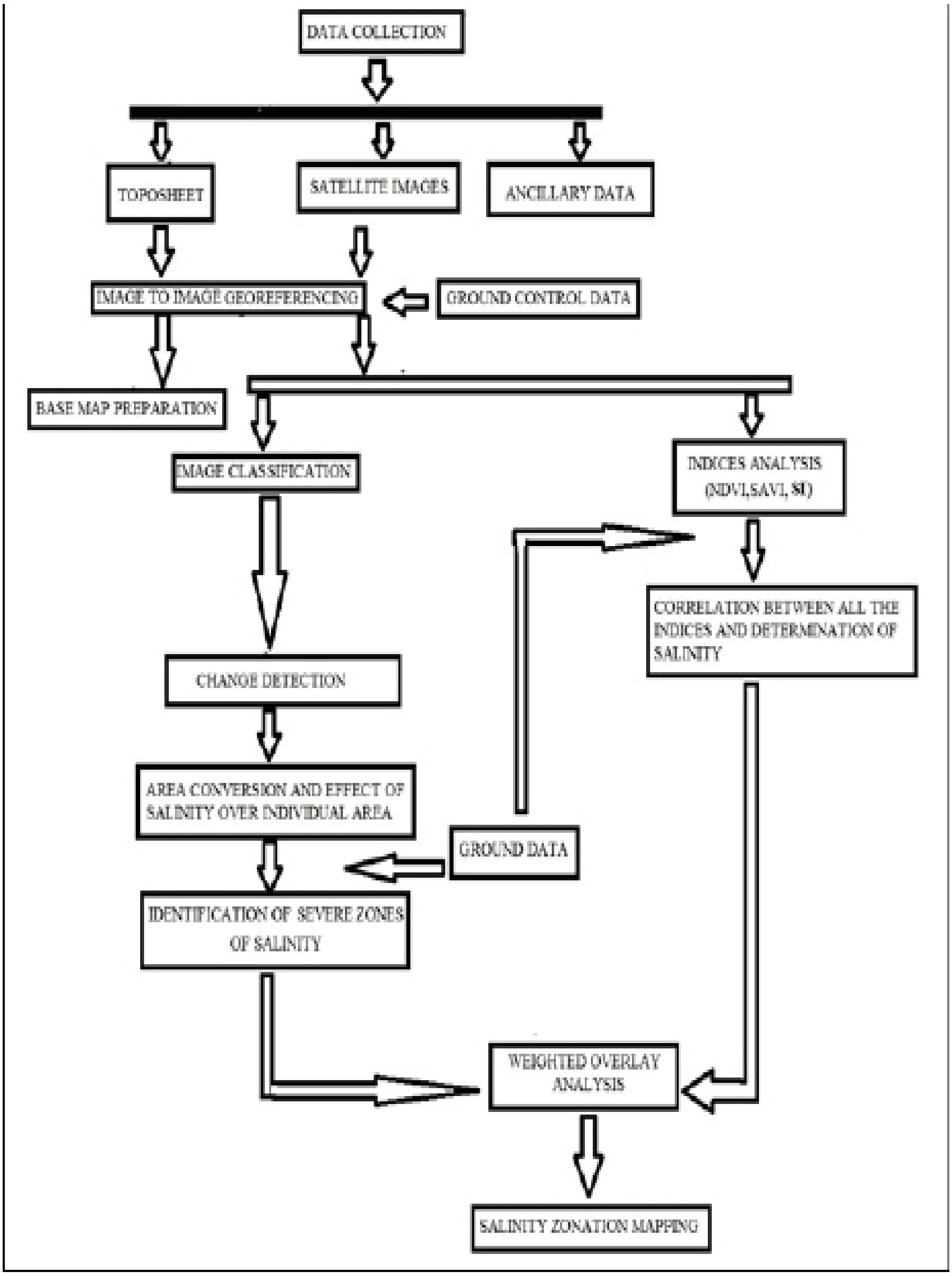

DATA COLLECTION
TOPOSHEET
SATELLITE IMAGES
ANCILLARY DATA
IMAGE TO IMAGE GEOREFERENCING
GROUND CONTROL DATA
BASE MAP PREPARATION
IMAGE CLASSIFICATION
INDICES ANALYSIS (NDVI,SAVI, SI)
CORRELATION BETWEEN ALL THE INDICES AND DETERMINATION OF SALINITY
CHANGE DETECTION
AREA CONVERSION AND EFFECT OF SALINITY OVER INDIVIDUAL AREA
GROUND DATA
IDENTIFICATION OF SEVERE ZONES OF SALINITY
WEIGHTED OVERLAY ANALYSIS
SALINITY ZONATION MAPPING

Fig.2.2 Flow Chart for Methodology

Data collection

The spatial data and some other ancillary data were collected for the project work to be carried out for further analysis. The Satellite imageries of Landsat MSS (1975), Landsat ETM+ (2000), Landsat TM (2010) were downloaded with respective path and row values from USGS GLOVIS website as shown in Fig. 2.3, 2.4 & 2.5. Soil map for reference were collected from National Bureau of Soil Science – Landuse Planning. The topographical maps from Survey of India were also collected. The rest of the data like soil samples with GPS positions were collected from the field and tested in laboratory method to derive parameters like pH ,EC,SAR.

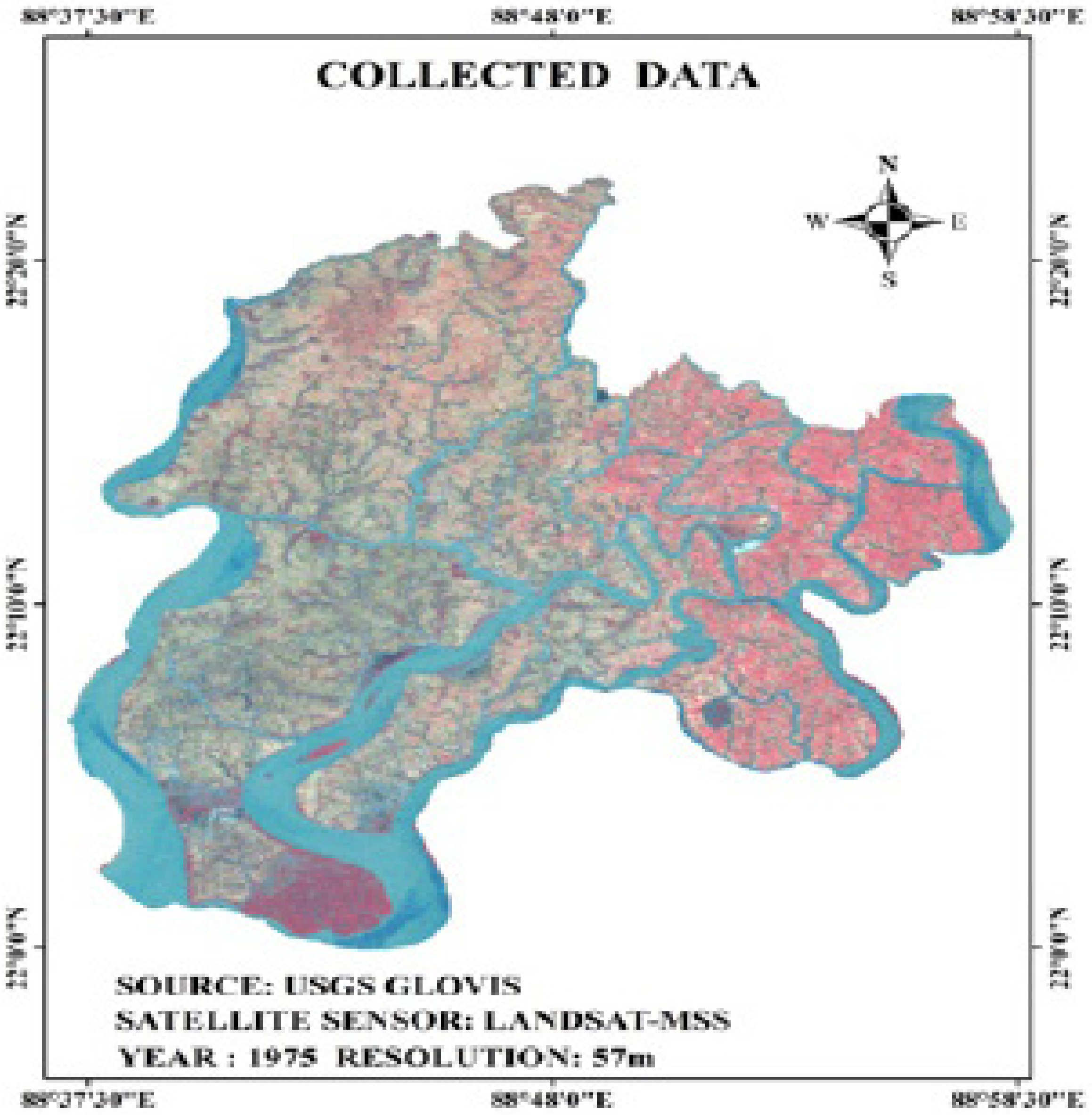
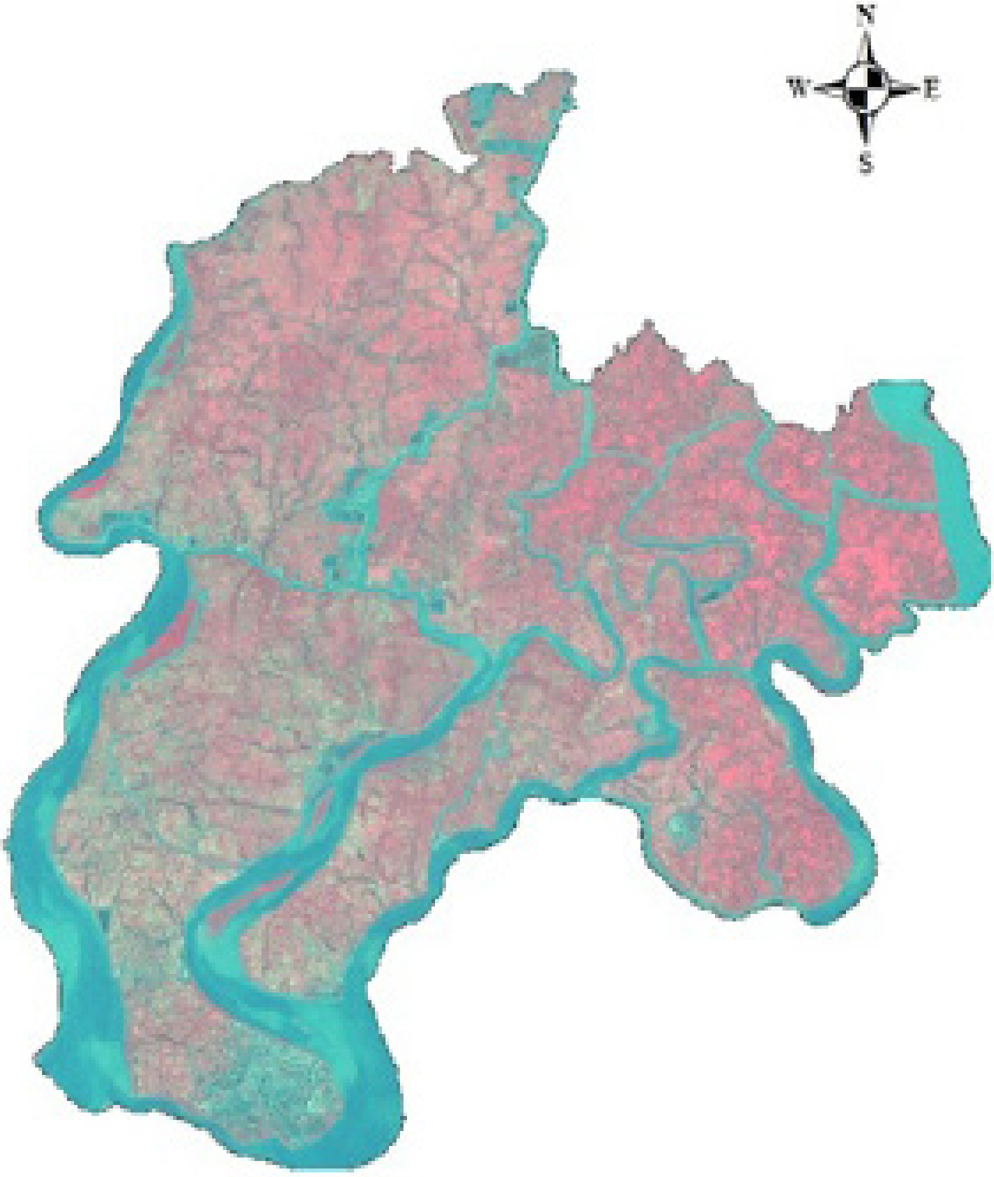
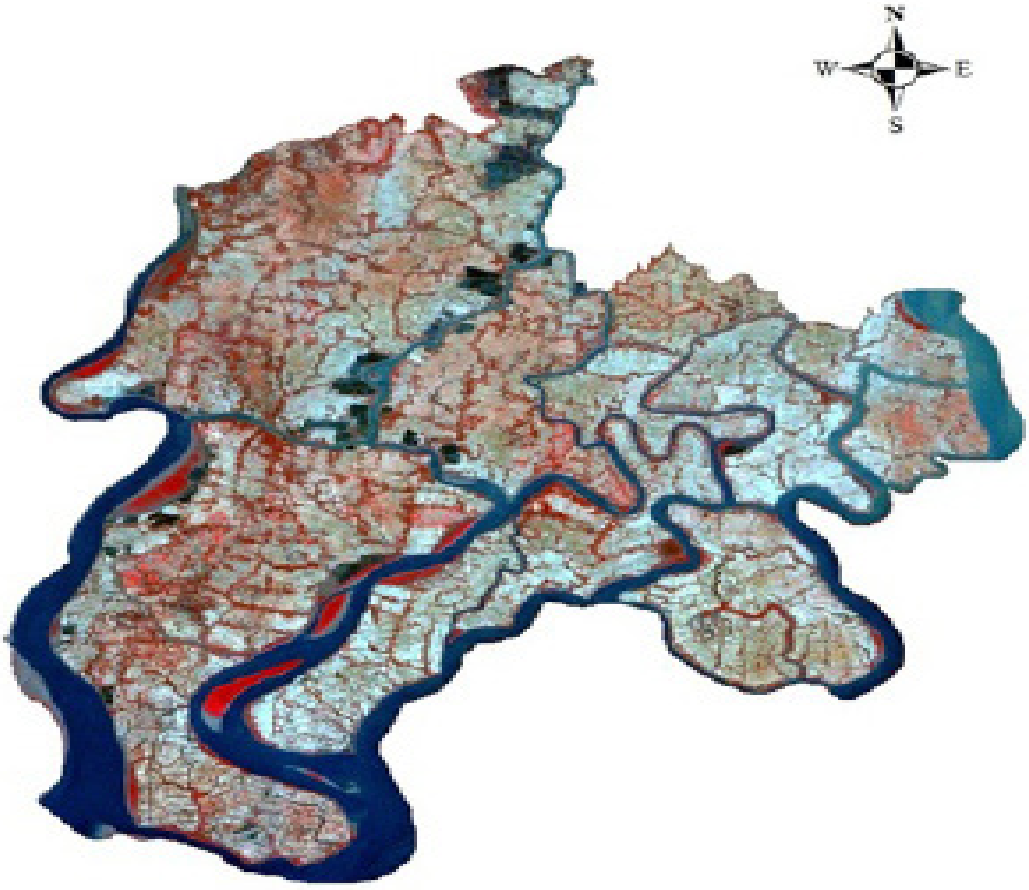


Fig.2.3. Satellite image 1975.



SOURCE: USGS GLOVIS
SATELLITE: LANDSAT SENSOR:ETM+
YEAR: 2000 RESOLUTION: 30m

Fig.2.4.Satellite image 2000



SOURCE: USGS GLOVIS
SATELLITE:LANDASAT SENSOR: TM
YEAR:2010 RESOLUTION: 30m

Fig.2.5.Satellite image 2010.

Preprocessing of Satellite Imageries

- Preprocessing techniques were adopted through Geometric Correction by image to image geo-referencing technique in Erdas Imagine (9.2) Image Processing Software, between Satellite images and Toposheet. The coordinate system Geographic lat-long/Wgs 84. The resampling process followed with Nearest Neighborhood Method. The Root Mean Square Error was in between 0.3-0.38. It showed the accuracy of the method in locating spatial location by choosing common geographical points(Ground Control Point) in Toposheet and corresponding satellite images of the same geographic location(study area).

- The subsetting of area of Interest was followed to extract the AOI from satellite images

Image Processing

- Classification over the Multi temporal images were done by Supervise Classification Method and using Maximum Likelihood Classifier. The training set were provided on the basis of field knowledge of landuses. The various classes of Landuse and Landcover were generated with the areal distribution (sq.km).

- The Change of areas in landuse and lancover were viewed from raster attribute data. The dominant effects of the salinity over the area and land conversion were viewed.

Graphical Representation of Change Detection of Landuse/Land Cover

It shows the graphical representation and change of spatial extent of each class of landuse and landcover with relation to the time. It can be positive with area increase where graphical data shows the increasing bar or negative where graphical data represents the decrease in bar graph due to area decrease.

Indices Analysis

Indices are the model which deals with the spectral reflectance of the spatial features in various wavelength of electromagnetic spectrum. It is the modernized technique to analyse the vegetation health, condition, soil condition through various reflectance's over wavelength.

Normalized Difference Vegetation Index

This index deals with the Reflectance of green cover in Near Infrared Band based on structure and water content present in the cover and absorption Of Red band due to presence of chlorophyl in the vegetation. The vegetation health can be analysed in good or poor condition. Over the salinization to create adverse effect on vegetation. This can be analysed through the NDVI.

$NDVI= NIR – R / NIR+ R$ (2.1)
(+1 = Good condition of vegetation health)
(-1 = Poor Condition in Vegetation Health)

Normalized Difference Salinity Index

This index also deals with the NIR band and Red band in assessing salinity condition due to salt effect over any area. The brightness values in white encrustation can be analysed as salt encrusted land.

$SI = (RED –NIR/RED+NIR)$ (2.2)

Soil Adjusted Vegetation Index

This index accounts for minimizing the effect of soil in acquiring 100% reflectance from vegetation. It is effective in analyzing vegetation and soil condition by incorporating L as the correction factor to improve on NDVI. If L = 0 then NDVI = SAVI

$SAVI = (NIR – R) (1+L)/ (NIR+R+L)$ (2.3)

These indices are important in salinity zone determination and can be done through the Image Processing Software (Erdas Imagine) through modeler or indices.

Correlation between different Indices

By inputting the values of two indices in graphical method correlation can be es tablished. The relationship between SAVI and NDSI can be analyzed. Where the salinity is higher the health of the vegetation is affected showing negative values in NDVI/SAVI. It is the process of correlating two individual variables and building relationship between them.

Ground Sampling Method

By analyzing the various soil type along with hydrological soil group the sample of soil were collected from scattered location along with the GPS Positions (latitude & longitude).

Sample Testing In Laboratory Method

The pH, Electrical Conductivity, Sodium Absorption Ratio level of individual soil type over the collected points were measured in laboratory method to test the salinity. The data values were recorded in the database.

GIS APPLICATION

Digitization

It is the method of converting analog data to digital form. The digitization of boundary of the study area along with drainage, water bodies, Road network were followed in ARC GIS 9.3 software by creation of Personal Geodatabase with assigning the coordinate system and creation of feature dataset and feature classes for preparing base map.

Overlay Analysis Method

It is the method of overlaying two input features of same geographical location to achieve new output. Through this method the NDSI map and the measured Ph,EC values with the Collected GCP . points through GPS were overlaid to verify whether the remote sensing analysis due to salinity impact and measured salinity from ground sampling truth are matching. The accuracy of the work can be assessed and high, moderate, low zones of salinity were be achieved.

Weighted Index Overlay Analysis

It is a simple and stratified method for combining analysis of different themes. The weights are assigned according to the importance of themes with respect to the objective (salinity zone identification). The weightage of each parameter (SAVI,NDSI , Landuse Classes) were decided on the basis on ranges of the maximum and minimum values of each parameter. Total weightage were divided into different zones of salinity like High, Moderate, poor.Finally,from the weighted overlay analysis of 1975,2000,2010 salinity identification and zonation were performed at the final stage of the research work.

Preparation Of maps

The final output map of salinity zonation was displayed through software along with other reference maps .The map composition technique were followed to show map with spatial location, direction, scale, legend and of particular theme.

MATERIALS REQUIRED

Landsat Multi spectral Sensor data of 1975 of 57 m, Ladsat Thematic Mapper of year 2010 of 30 m resolution and Landsat Enhanced Thematic mapper of the year 2000 along with other ancillary data and Survey of India Toposheet are required for the work which will be carried out in Erdas Imagine 9.2 Image processing software and ArcGIS 9.3 GIS software along with Global Positioning System (Trimble GPS Receiver) to collect geo-coordinates of an area with latitude, longitude and elevation. All the GPS points collected in the field were exported in point shape file in ARC GIS software to view on the image.

Satellite Images Characteristics

The detailed characters of sensor for collected satellite image is given in Table 2.1

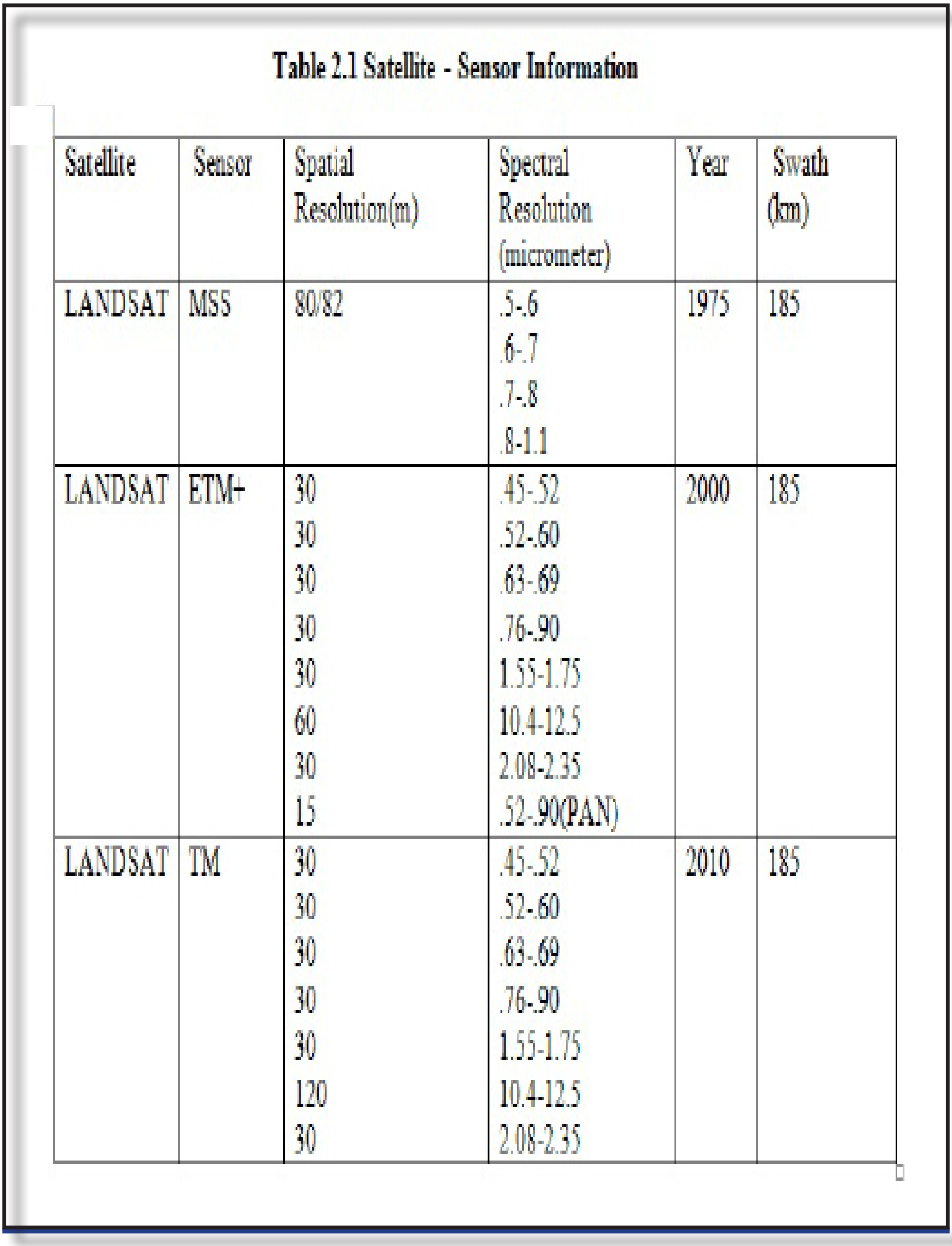


Table 2.1 Satellite - Sensor Information

Satellite	Sensor	Spatial Resolution(m)	Spectral Resolution (micrometer)	Year	Swath (km)
LANDSAT	MSS	80/82	.5-.6 .6-.7 .7-.8 .8-1.1	1975	185
LANDSAT	ETM+	30 30 30 30 30 60 30 15	.45-.52 .52-.60 .63-.69 .76-.90 1.55-1.75 10.4-12.5 2.08-2.35 .52-.90(PAN)	2000	185
LANDSAT	TM	30 30 30 30 30 120 30	.45-.52 .52-.60 .63-.69 .76-.90 1.55-1.75 10.4-12.5 2.08-2.35	2010	185

Field Data collection

- pH is measured by collecting soil sample from the field.
- Sodium Absorption Ratio
- Electrical Conductivity (ds/m).

SOFTWARE USED

- ERDAS IMAGINE 9.2
- ArcGIS 9.3
- TNT Mips
- MS Office

INTRODUCTION OF STUDY AREA

The study area (Fig.3.1) is identified on South 24 Parganas district is an important district of West Bengal State with its district headquarters in Alipore. It has the urban fringe of Calcutta on one side and the remote river-line villages in the Sundarbans. Agriculture, Industry and Pisciculture are all at their peak in the district. The Area of the study lies part of the South 24 Parganas District.The study area GOSABA and BASANTI (South 24 Parganas) is bounded by the latitudes 21°29´00˝ N and 22°30´00˝ N and longitudes 88°30´00˝ E and 89°00´0˝E with an areal extent of 808.314 sq.km as shown in Fig.3.1. Gosaba and Basanti are the main deltaic islands in the Sundarban region, bounded by the Matala and Zilli rivers/ creeks and mangrove forest.

PHYSIOGRAPHY OF STUDY AREA

Geology

The Geological formation of the Island is of comparatively recent origin (Curtis 1924). Many years back the whole was submerged under the sea. The formation with deposition occurred with recent changes of the main course of River Ganga. This was because of the result of neotectonic movement (Morgan & Melanie, 1959 Mgmt. Plan of S.T.R. during 1977 – 98) on Bengal Basin and an easterly tilt.

Ecogeography and Water Resource

The main rivers Matla and innumerable creeks network are distinctive features in the two Island Branching tributaries of creek systems have a prefect pattern over the salt marshes. Meandering were identified in the study area stream network. All rivers have a southward course towards the sea. Tidal effect dominates over the eco-geography of the area. Two flow tides and two ebb tides outing within 24 hours with the tidal range 3-5 m and up to 8m (Ghosh & Mandal, 1989; Banerjee 1998) in normal spring tide, inundating the whole of Sundarbans in varying depths.

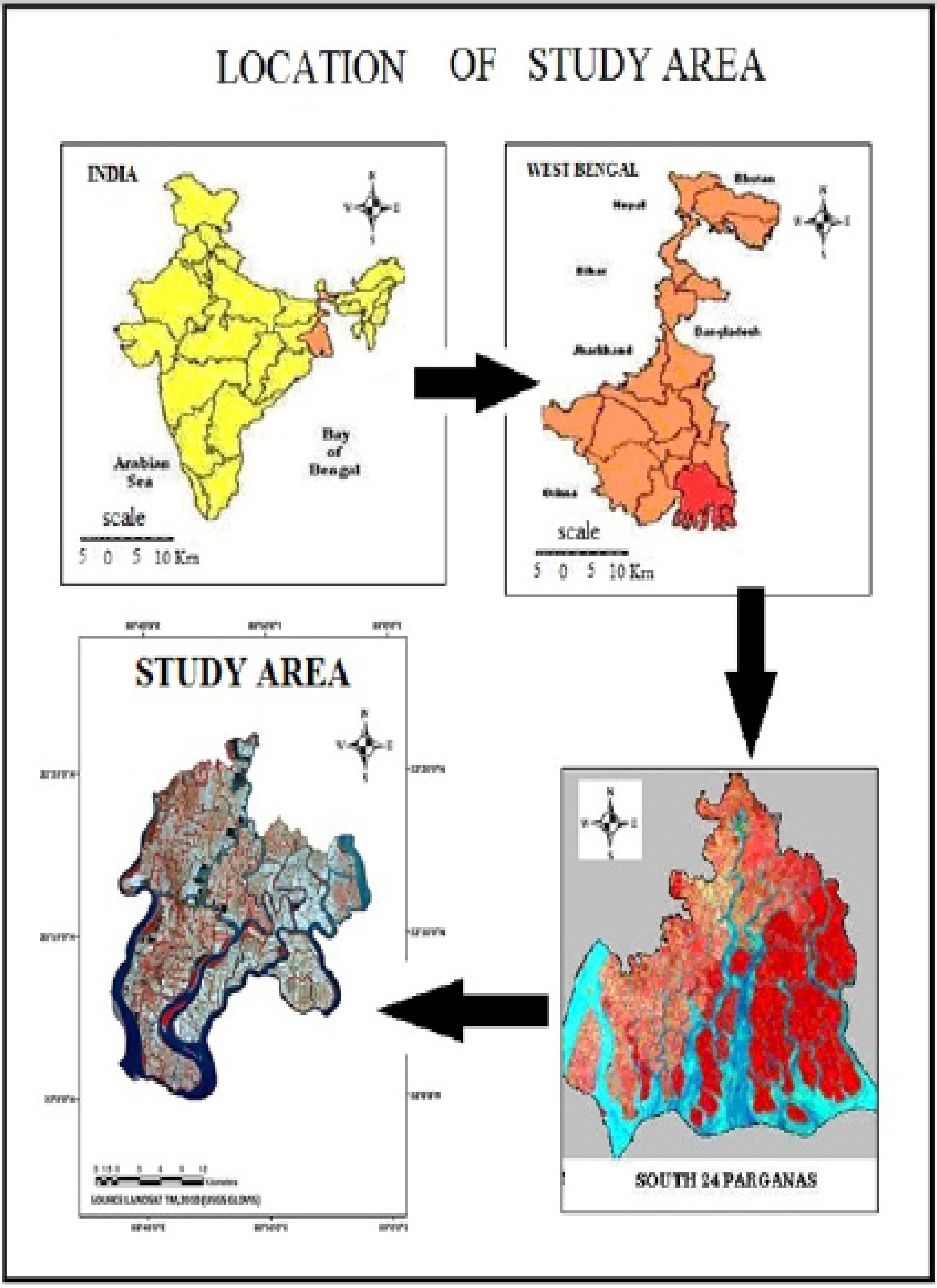


Fig 3.1 Location Index of Study Area

Soil Type

In Gosaba and Basanti Island soil show sandy clay loam type. In the reclaimed areas soils are saline in nature clay loam and sandy loam textures were found in coastal marsh patches of island.The major soil textures are coarse loamy,Fine loamy,sandy clay,silty clay,silty loam.The hydrological group A,B,D is predominating over the area.

Land use / land cover

The land cover type shows by dense forest, mangrove forest, marshy land, salt pan, natural drainage over the areas and land use types are agricultural land, fallow land.

Climate

The average maximum and minimum temperature is 34˚C and 20˚C respectively. The monsoon lasts from mid June to mid – September. Storm which sometimes develop into cyclones are common during the month October.

BASE MAP PREPARATION

The permanent features over the study area were shown through the base map (Fig.3.2). It is consisting of Administrative Boundary, Road Network and Drainage (Matla river, Bidya River) along with the major locations. The total geographical area within the boundary 808.314 sq.km was obtained through GIS software.

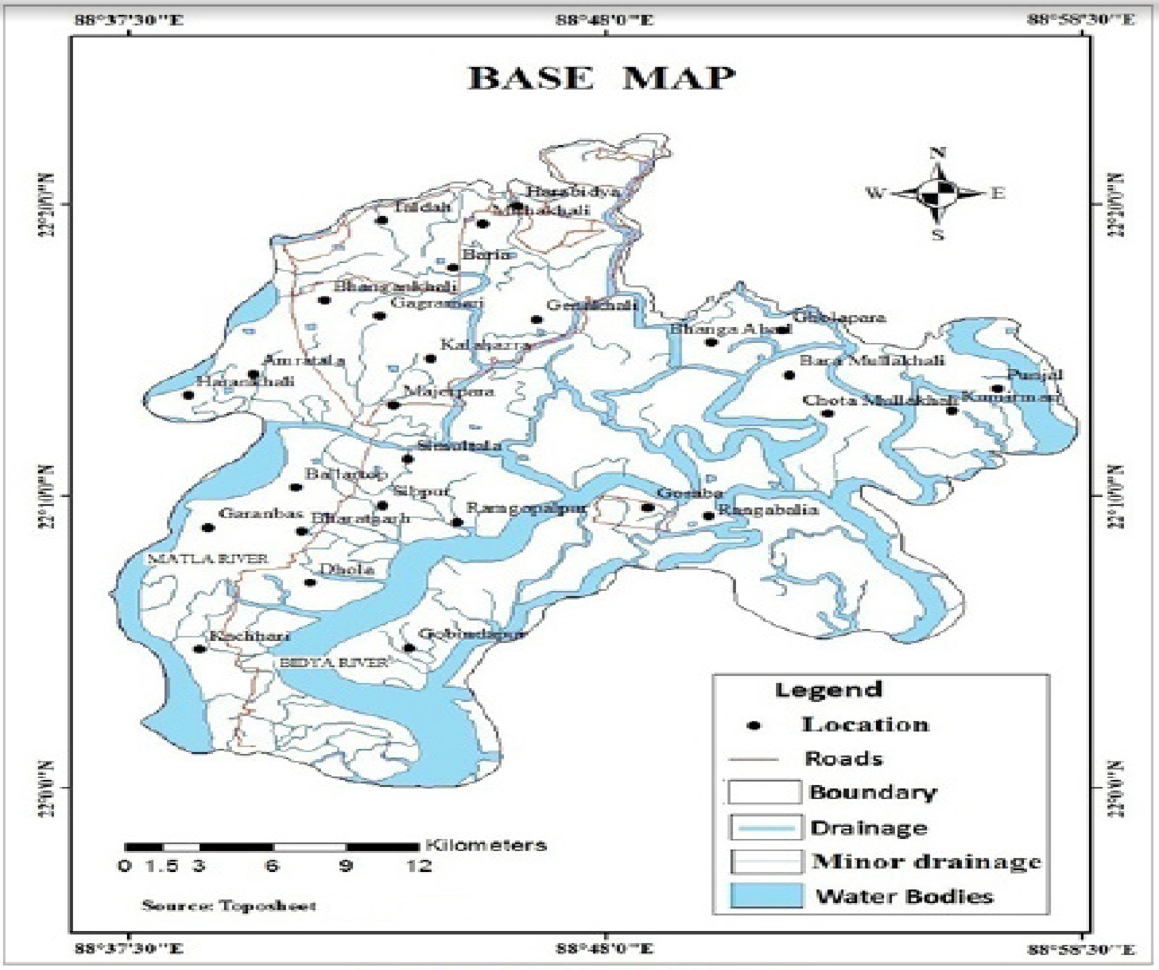


Fig 3.2 Base Map of Study Area

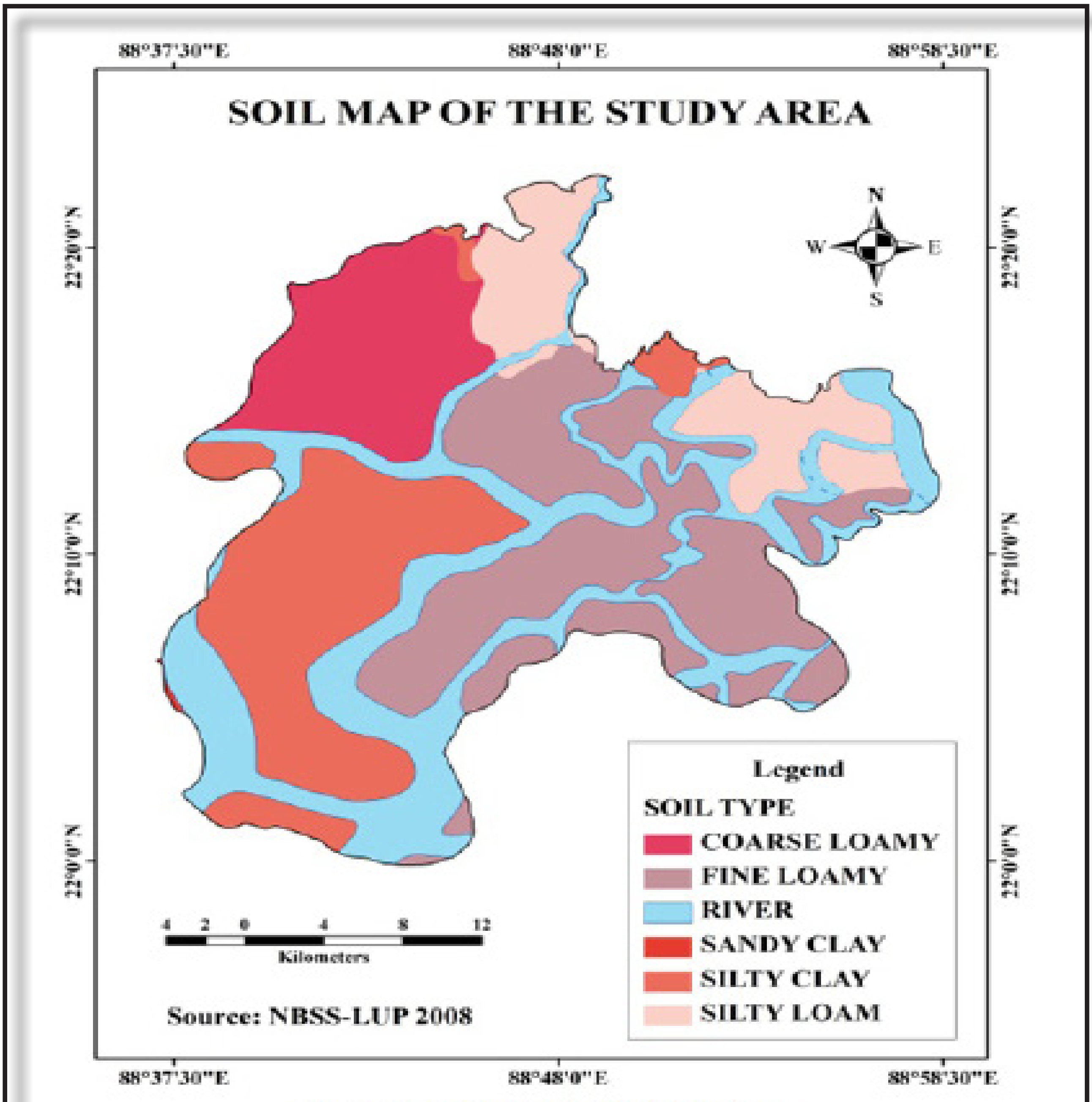
RESULTS AND DISCUSSIONS

GENERAL

The following results were obtained at the end of the Project. The works were carried out in Erdas Imagine and Arc GIS software.

Soil Map

The soil map (Fig.4.1) of the study zone shows loamy, silty, clay types of soil. The zonations were done on ArcGIS through digitization and separating each soil type by its attribute with soil type data acquired from NBSS-LUP. It is the result of the disintegration of the upper part of the earth under the natural forces. The major soil type which has occupied 362.64 sq.km of the area is Fine Loamy soil and lowest soil distribution is 50.64 sq.km is covered by Silty Loam soil.



Source: NBSS-LUP 2008

Figure 4.1 Soil Types of Study Area.

Hydrological Soil Groups

The texture classes of the soils in the study area were re-classified into hydrologic soil groups (HSG's) as depicted in Table 4.1 to indicate the minimum rate of infiltration obtained for bare soil after prolonged wetting. There are three soil HSG's, namely A, B, and D are the elements used in determining runoff curve numbers. The soil group A is occupying major area as 362.64 sq.km, B is occupying 50.64 sq.km area and D is minimum area distribution of 177.9sq,km area. A group is dominating group in which the high infiltration zones will indicate the water logging this island soil.

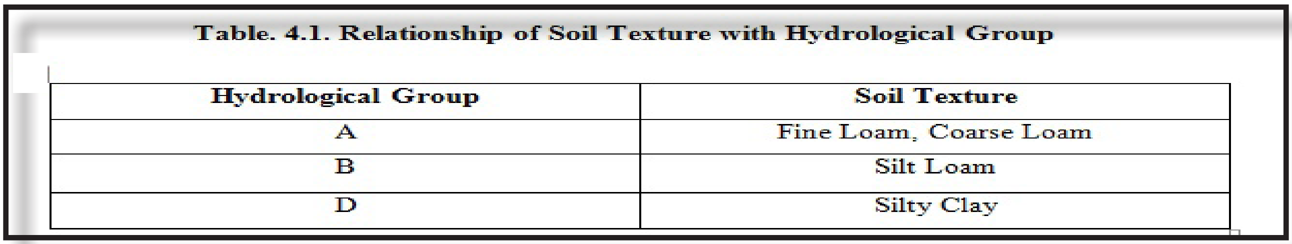


Table. 4.1. Relationship of Soil Texture with Hydrological Group

Hydrological Group	Soil Texture
A	Fine Loam, Coarse Loam
B	Silt Loam
D	Silty Clay

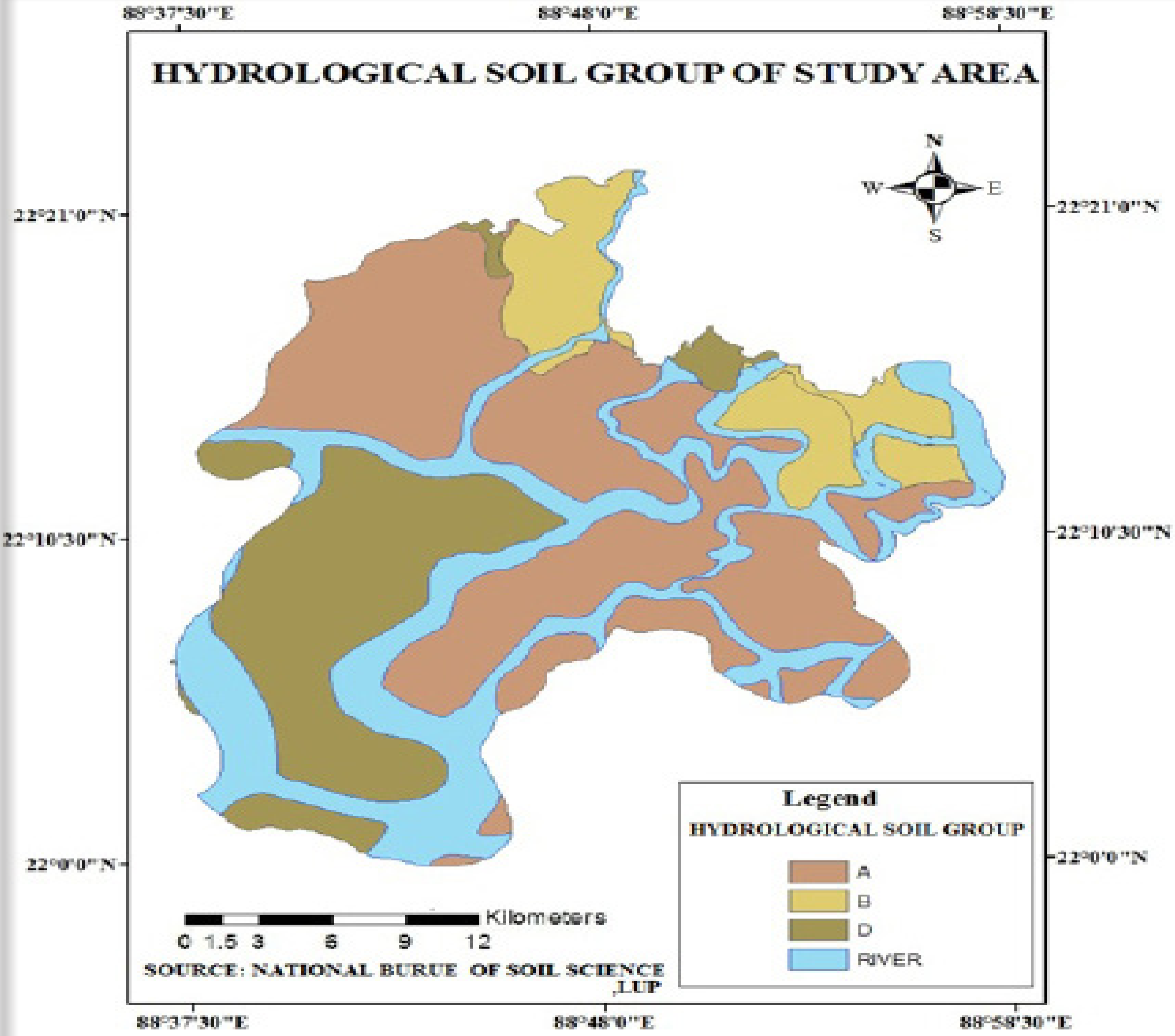
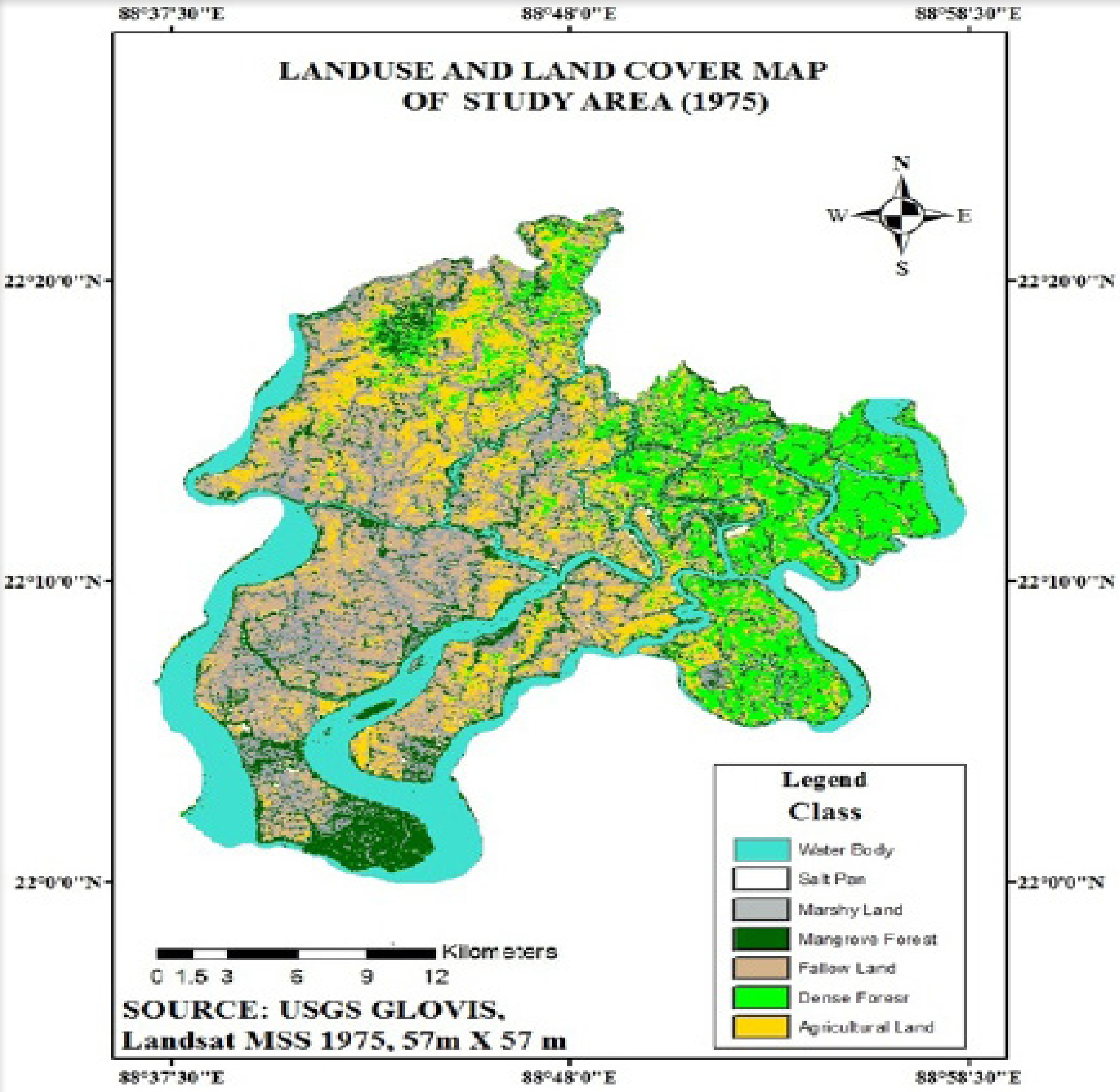


Fig.4.2 Hydrological Soil Group of Study Area

Landuse / Land Cover Map of Study Area

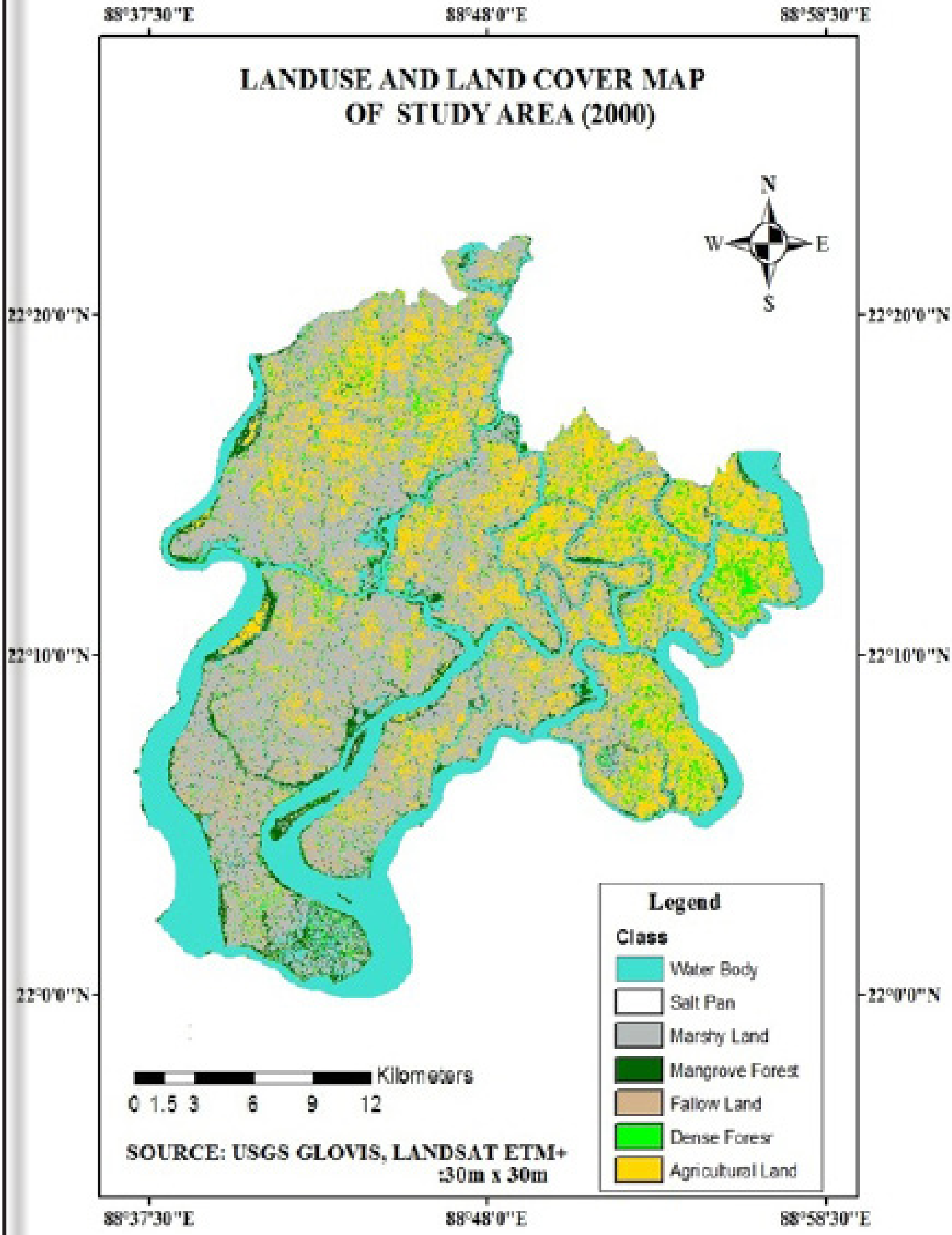
Through the image processing system in Erdas Imagine Software the classification on spatio temporal satellite images from the year 1975 to 2010 with Supervised Classification Technique and maximum likelihood classifier and by assigning training sets the different classes with spatial extension and different tonal variation were achieved. The landuse/ landcover map of 1975,2000,2010 were depicted in Fig. 4.3, 4.4. & 4.5.

Landcover is the natural space over the earth surface .e.g – Natural Dense Forest Land,Mangrove Forest,Salt Pan, Marshy land,natural water bodies were found over the area. When they are converted into the land require meeting the need of human by human induced method, they are called the landuse which were found in terms of agricultural land and fallow land.



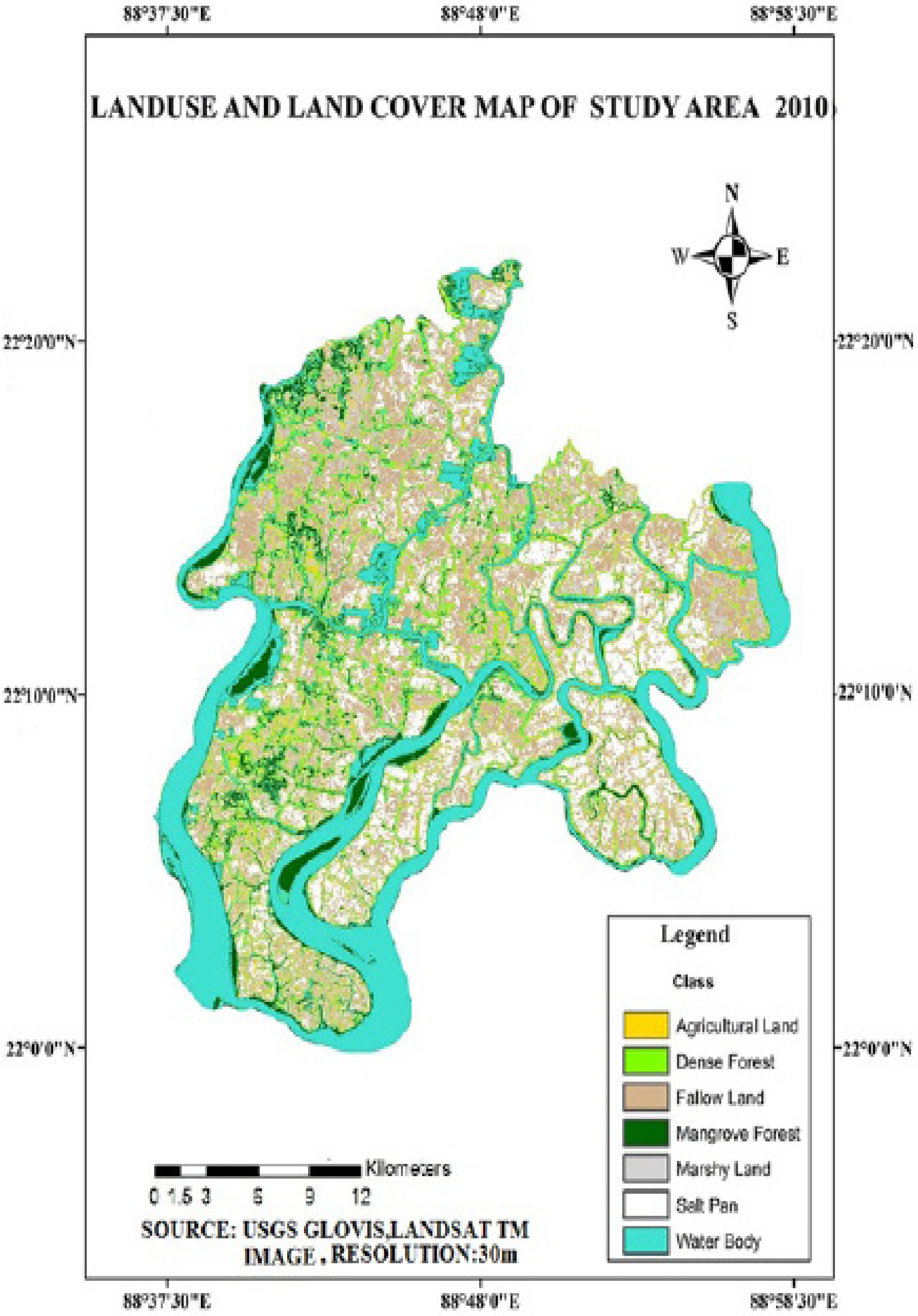
SOURCE: USGS GLOVIS,
Landsat MSS 1975, 57m X 57 m

Fig.4.3 Landuse / Landcover map of 1975



SOURCE: USGS GLOVIS, LANDSAT ETM+ :30m x 30m

Fig.4.4 Landuse / Landcover map of 2000



SOURCE: USGS GLOVIS,LANDSAT TM IMAGE , RESOLUTION:30m

Fig 4.5 Landuse / Landcover map of 2010

Change Detection

The graphical representation (Fig.4.6) of the areal cover of the landuse were generated through classification process which is showing individual areas of that class. The natural land like water body has changed over the years and decreased over the space. Mangrove Forest has decreased immensely and estimated from 145 sq.km to 66.51sq.km over the three decades. Dense forest has decreased from 117.36sq.km to 67.42 sq,km whereas, the fallow land has increased from 19.87 to 163.61 sq.km. Salt Pan also has increased from 6.52 sq.km to 155.63 sq.km, Agricultural land has decreased from 115.84sq.km to 70.6 sq.km.

The scenario shows the change over the areas due to impact of over salinization as well as human induced processes over the study area. The Mangrove and other forest areas are reduced from 1975 to 2010 whereas the agricultural land, salt encrusted areas, fallow land were increased from 1975 to 2010.

The agricultural lands were converted to fallow land immensely due to over fertilization by human induced method over the lands. The forest cover decreased due to salinity as well as the forest clearing.

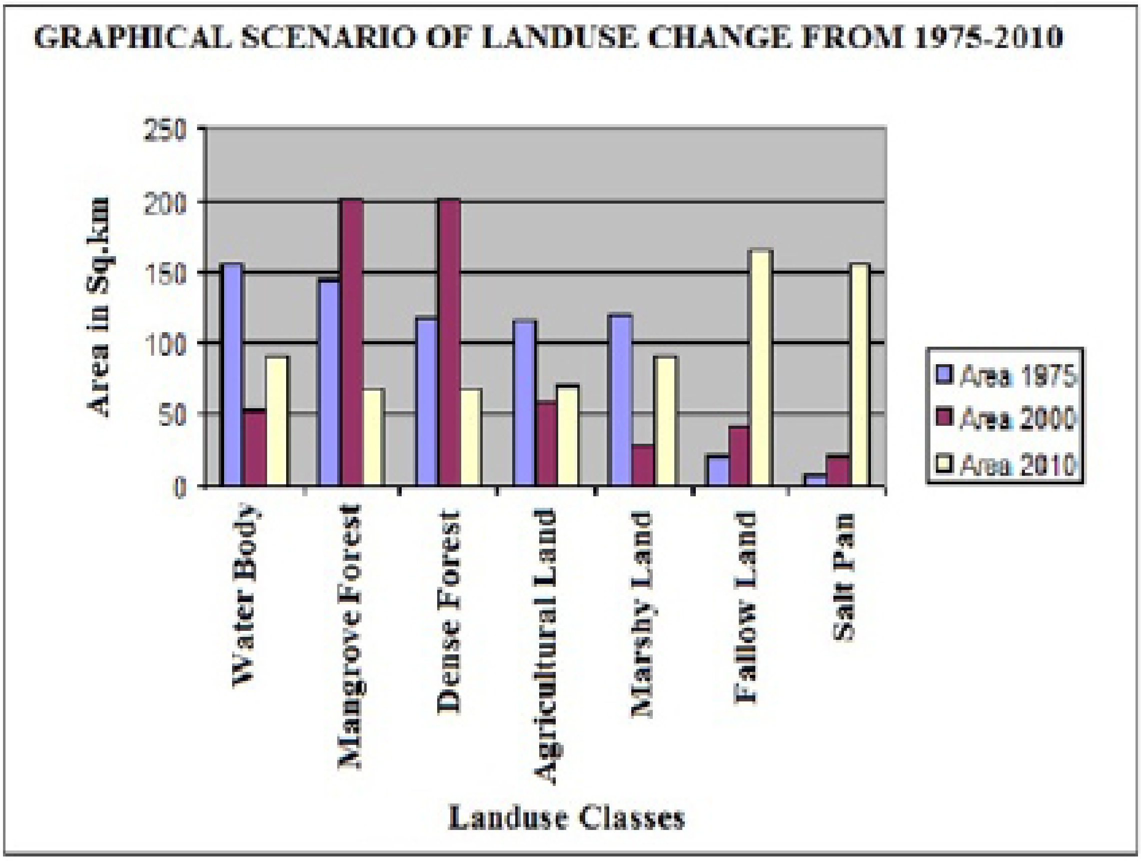


Fig. 4.6 Graphical Representation of Changes in areas of Landuse/Landcover from 1975, 2000 & 2010

Normalized Difference Vegetation Index (NDVI)

The NDVI was used with the Landsat Multispectral Scanner (MSS,1975) ,Landasat TM (2010),Landsat ETM(2000) and made use of channels 3 (red) and 4 (NIR). The NDVI identified the photosynthetic affinity or 'greenness' of the vegetation through the reflective proprieties of the chlorophyll and mesophyll layers within the plants in the NIR and red part of the EM spectrum. The NDVI value ranges from +1 (high value,healthy condition of vegetation) to -1(low value,Poor Condition of vegetation) and between +1 to -1 (denotes moderate condition of vegetation) .

In the year 1975 (Fig.4.7) very high,high values of NDVI was prevailing over the north eastern part near Punjal , Kumaramari,Harabidya where as moderate condition was visible over western and southern and as well as on central part Ballartop,Kachchari areas and low condition and very low was taken over mainly water bodies.In The year 2000 (4.8) again the very high and high condition was seen near eastern and northern parts.But mostly the moderate condition of vegetation increased by the years and low ,very low condition was taken by water bodies where reflectivity is less.In The year 2010 (Fig.4.9) low and very low condition was visible in the north eastern and northern part.It indicates the the condition of vegetation got detoriated from the year 1975-2010.The other parts of study areas indicated moderate and high condition.

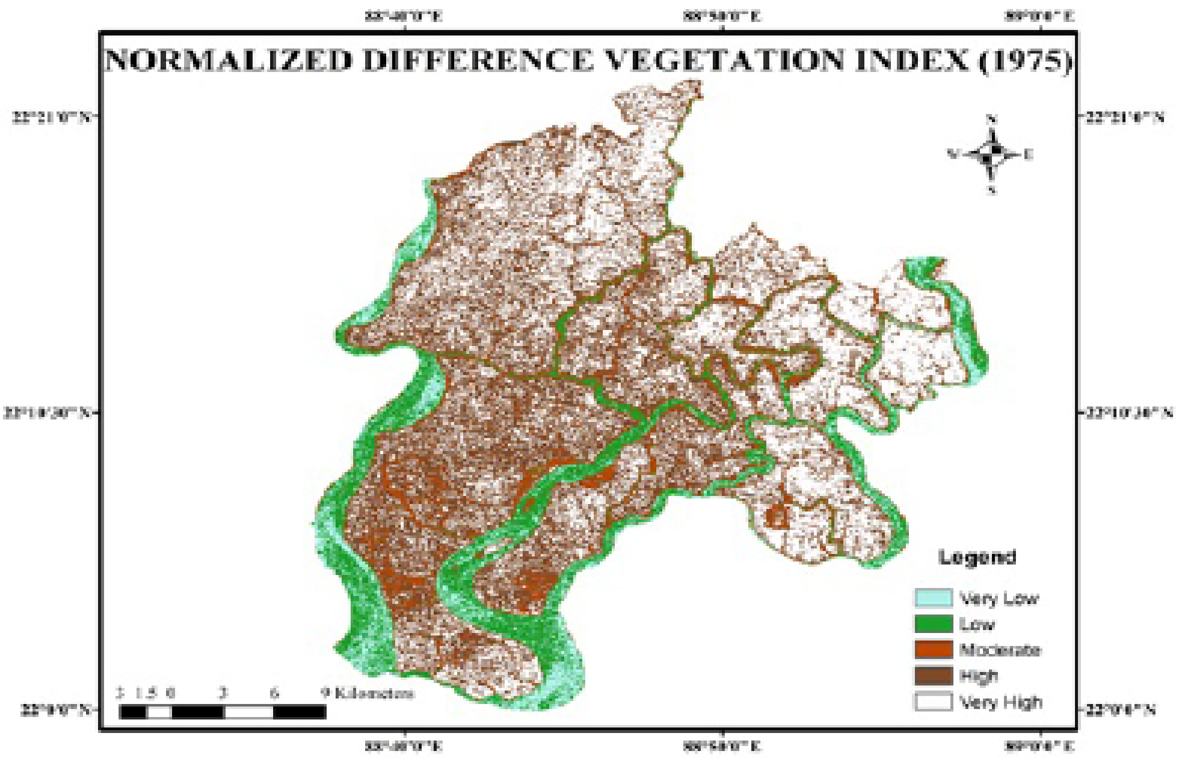


Fig.4.7. NDVI 1975

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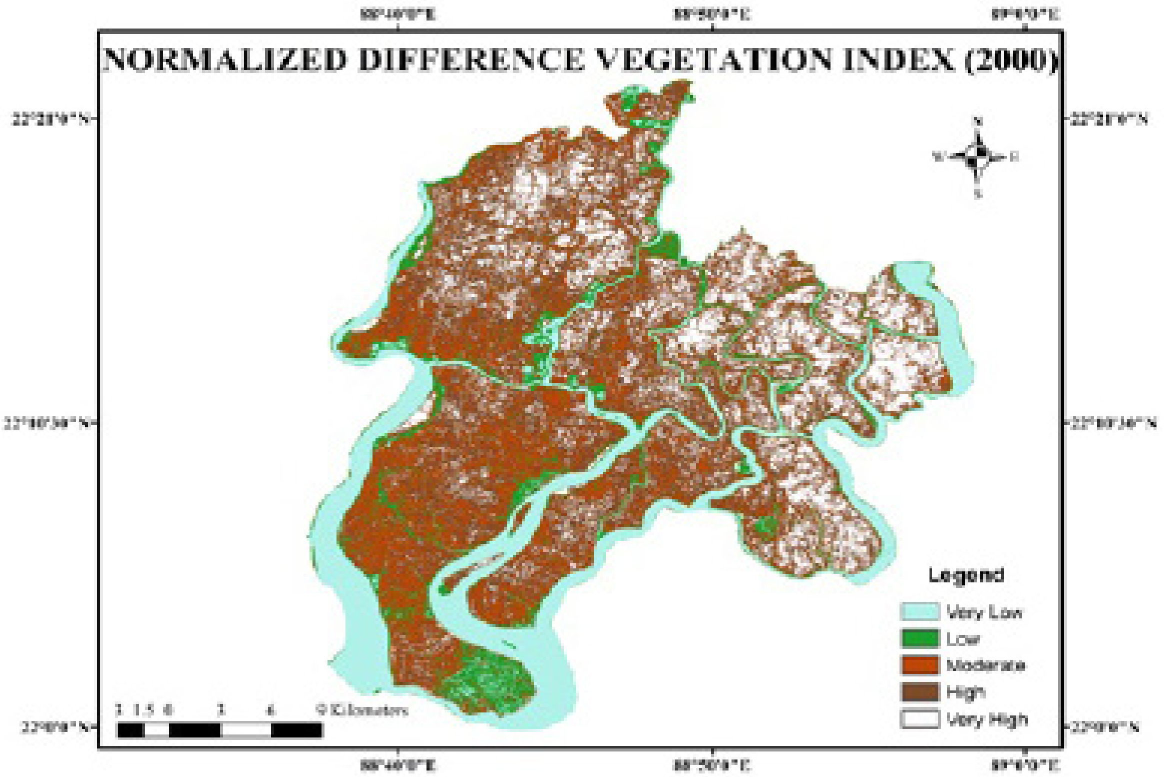


Fig.4.8. NDVI 2000

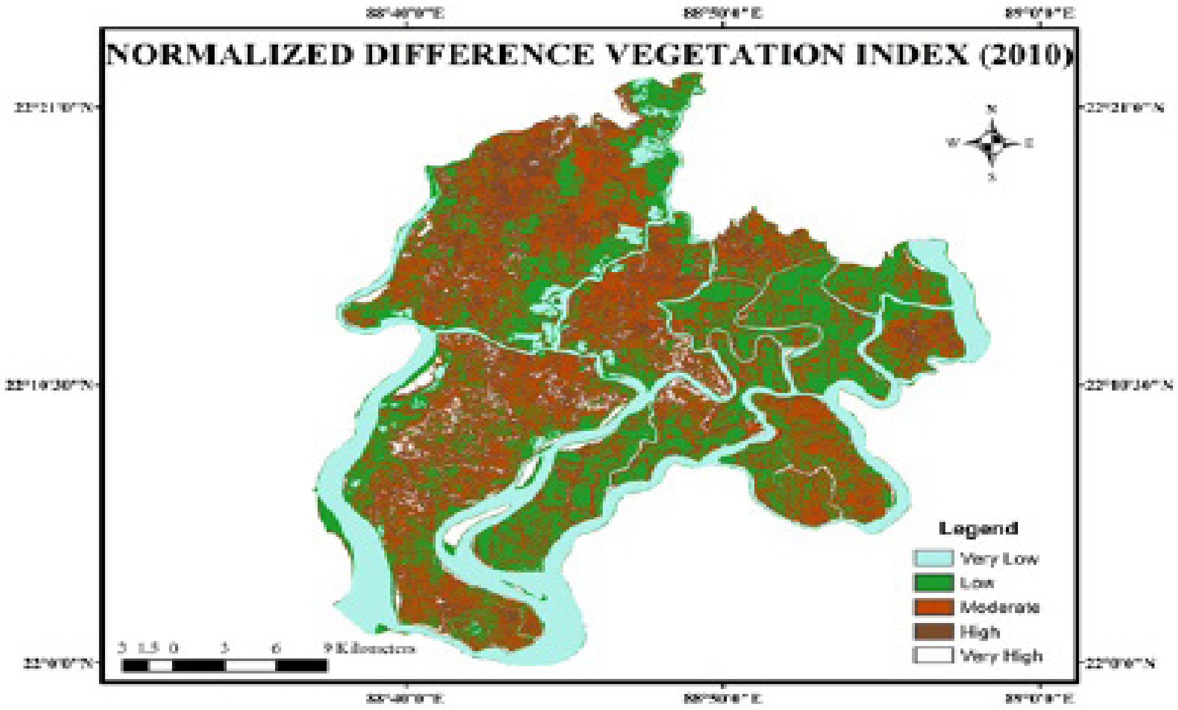


Fig.4.9.NDVI 2010

Soil Adjusted Vegetation Index (SAVI)

SAVI index were generated by designing model in Erdas Imagine software to eliminate the reflectance of soil background and to acquire 100% vegetation reflectivity.L,The correction factor (0.5) was contributed in the NDVI standardized formula to improve the result of NDVI.The output of SAVI of 1975(Fig.4.10),2000(Fig. 4.11),2010(Fig.4.12) showed the more or less same result as NDVI ,but the interpretability of output maps got improved. On the basis of values of SAVI the study area was interpreted with very high, high, moderate, low, very low condition like NDVI.

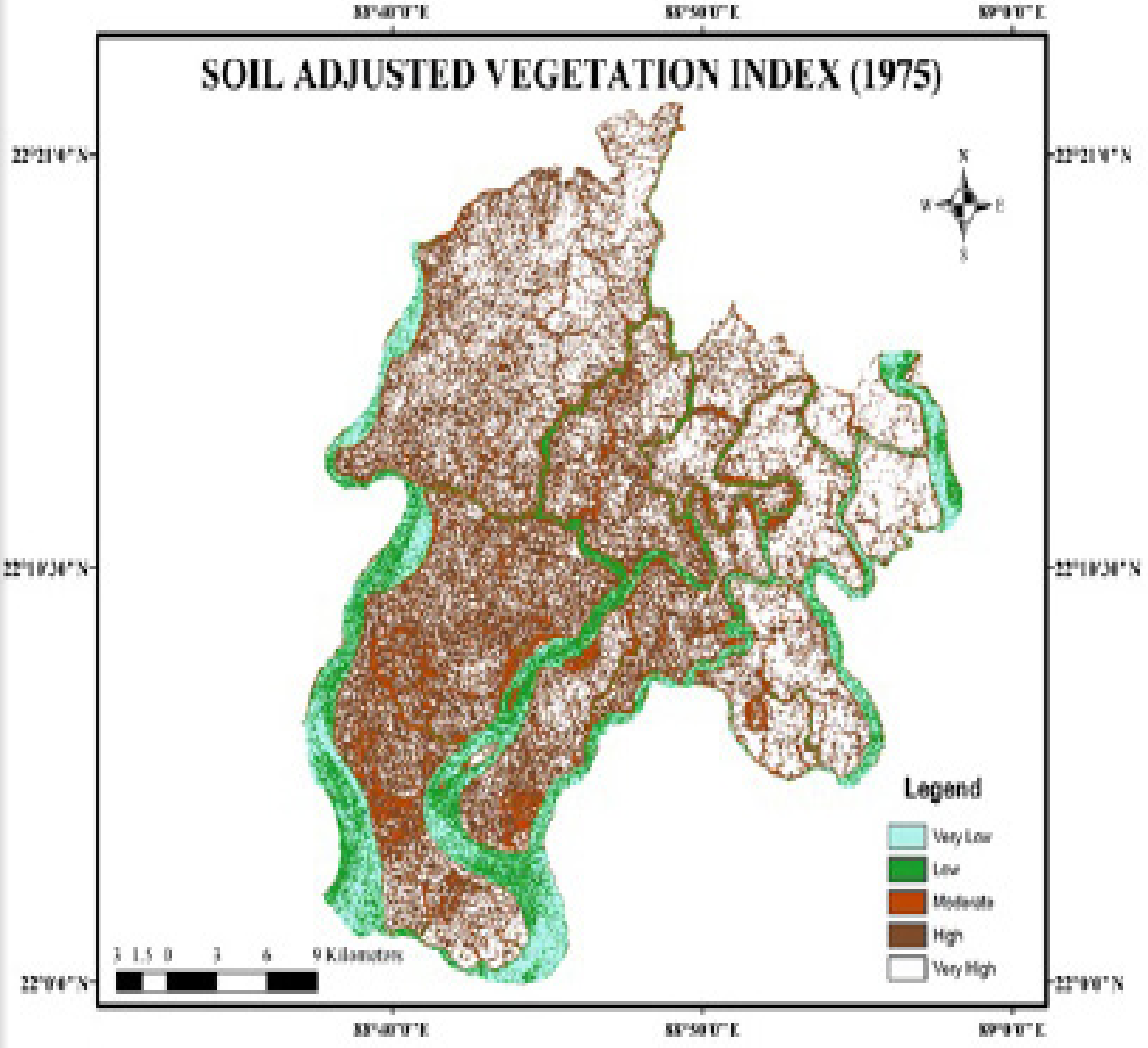


Fig.4.10 SAVI 1975

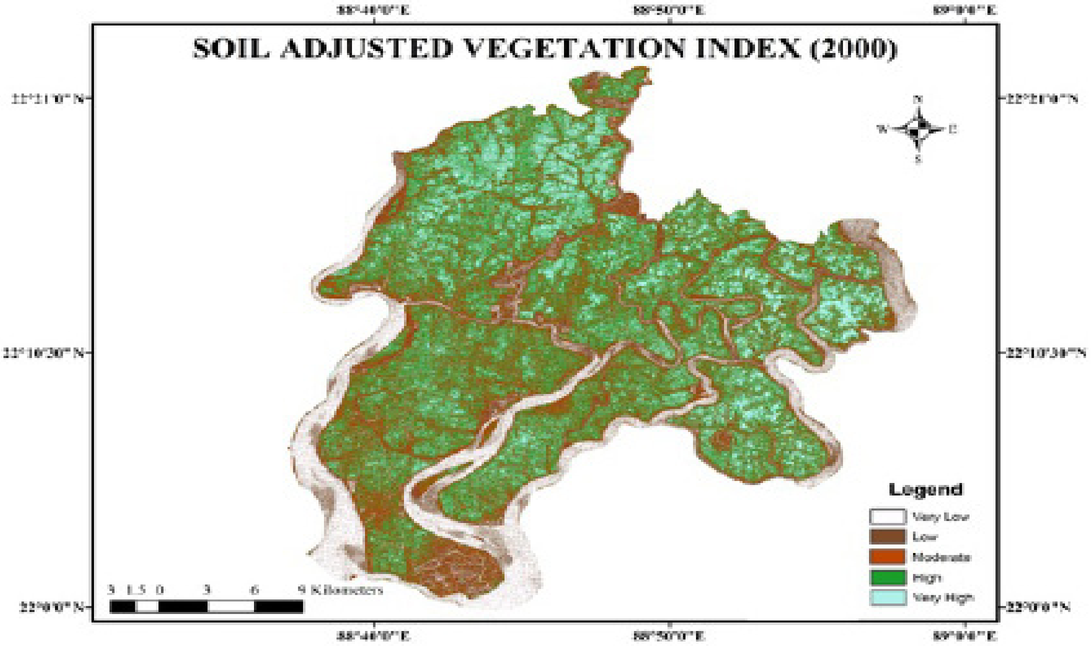


Fig.4.11 SAVI 2000

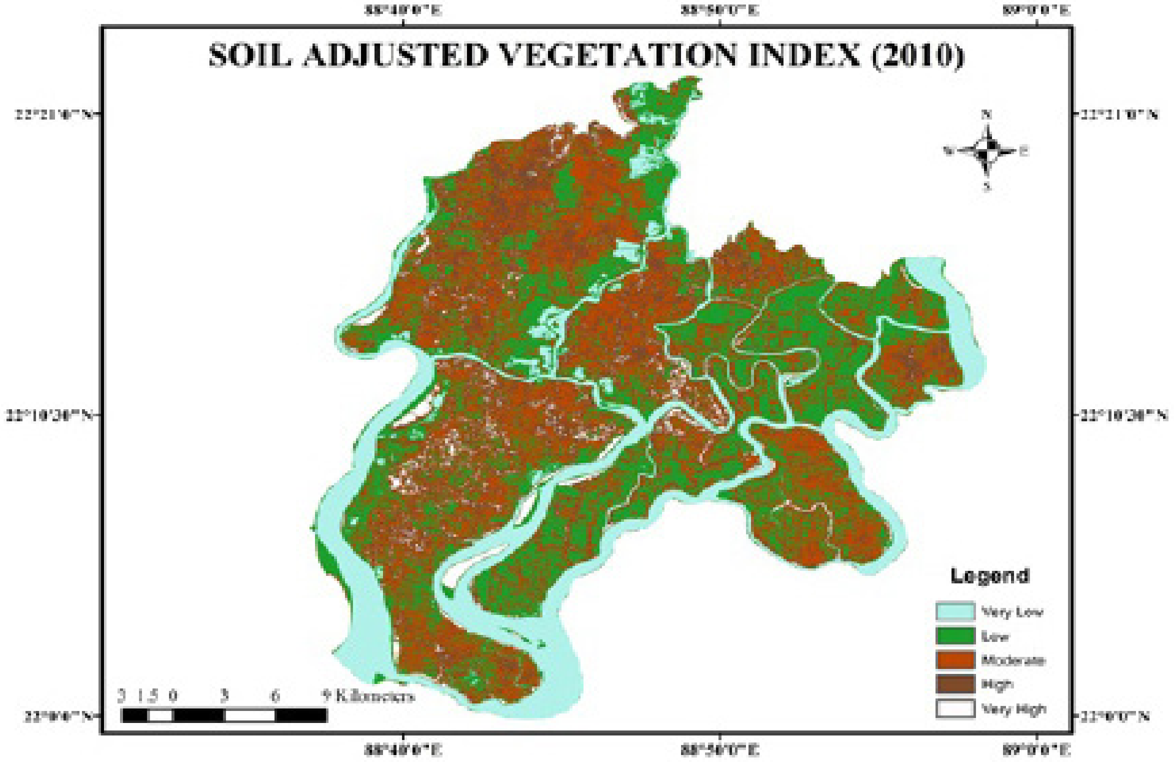


Fig.4.12 SAVI 2010

Normalized Difference Salinity Index (NDSI)

NDSI were generated considering the standardized accepted formula of NDSI to check the fluctuation in salinity condition from the year 1975 to 2010 by designing model in Erdas Imagine Software and value ranges between +1(highly saline condition) to -1(low saline condition).On this basis the zonation has been done like very low,low,moderate,high,very high.

In the 1975 NDSI (Fig.4.13) the very low salinity zones were mostly visible in the north east part.Otherwise the low condition persisted all over except the water bodies which showed the very high and high saline water.moderate amount of salinity condition were scattered all over the areas.Whereas in the 2000 NDSI map .(Fig.4.14) very low and low amount of saline conditions were noticed over the water surfaces and very high and high conditions in the north east and central and northern part and moderate amount were visible over the mangrove patches over the islands.In the year 2010 (Fig.4.15) immense changes were noticed in NDSI. Water in the riverine systems were occupied by very high saline condition and huge amount of land surface were engulfed by the high salinity and moderate condition also prevailed near central and northern and western part.Whereas the areas for very low and low saline land surface got decreased.The change in increasing of salinity at an alarming rate occurred from 1975-2010 due to devastating act of cyclone aila in the year 2009 as well as other small cyclonic activities during 1975-1999 which are responsible for dynamism over the coastal island like Basanti,Gosaba in Sundarban areas of West Bengal.

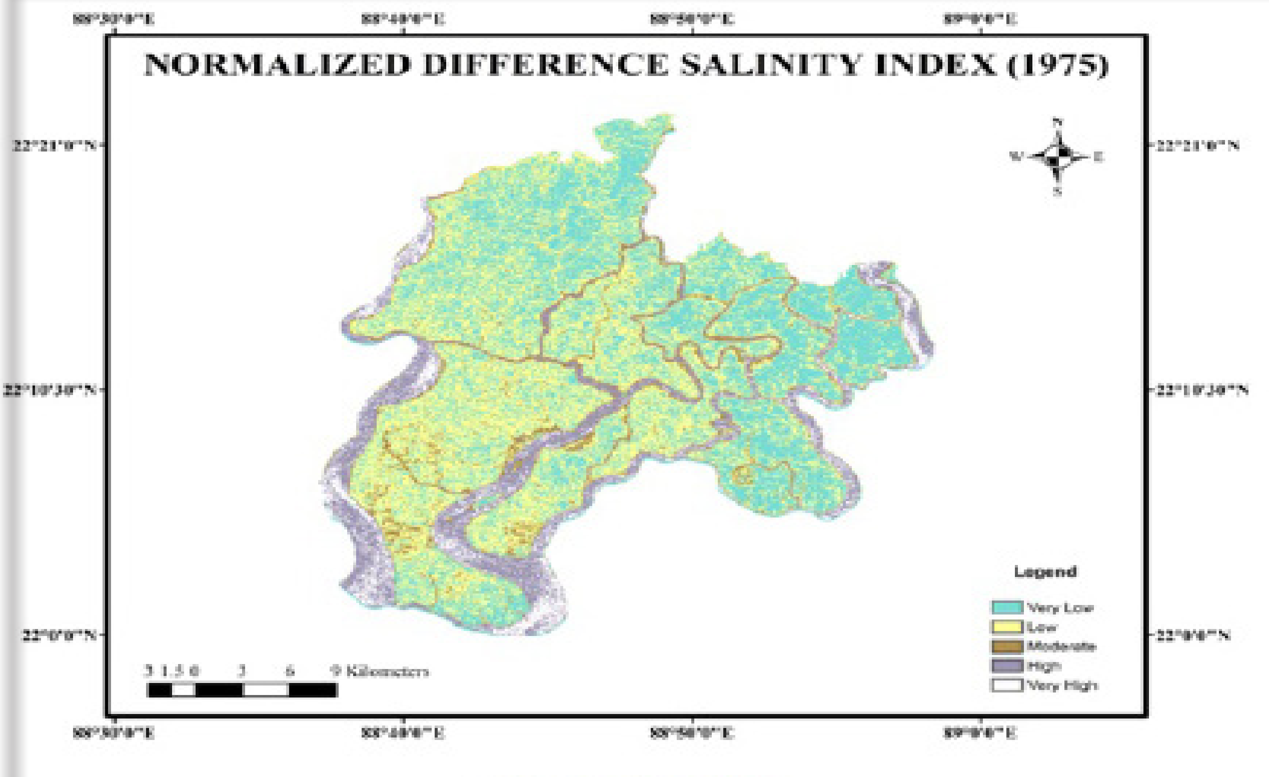


Fig.4.13 NDSI 1975

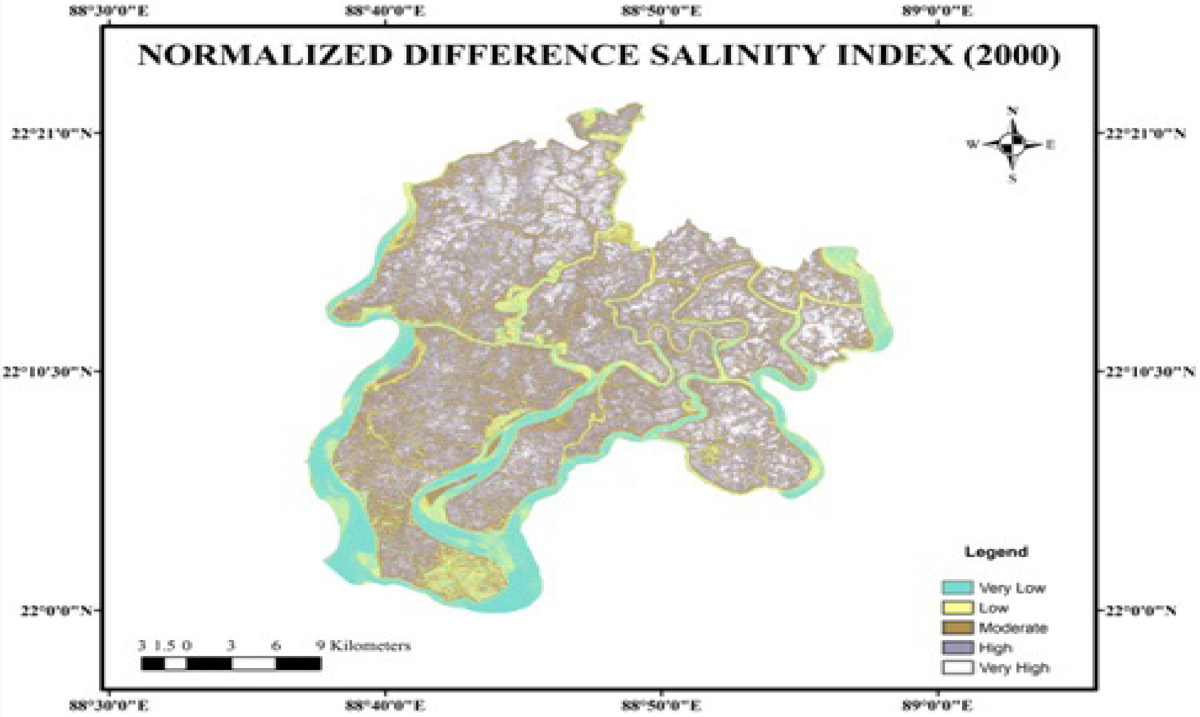


Fig.4.14 NDSI 2000

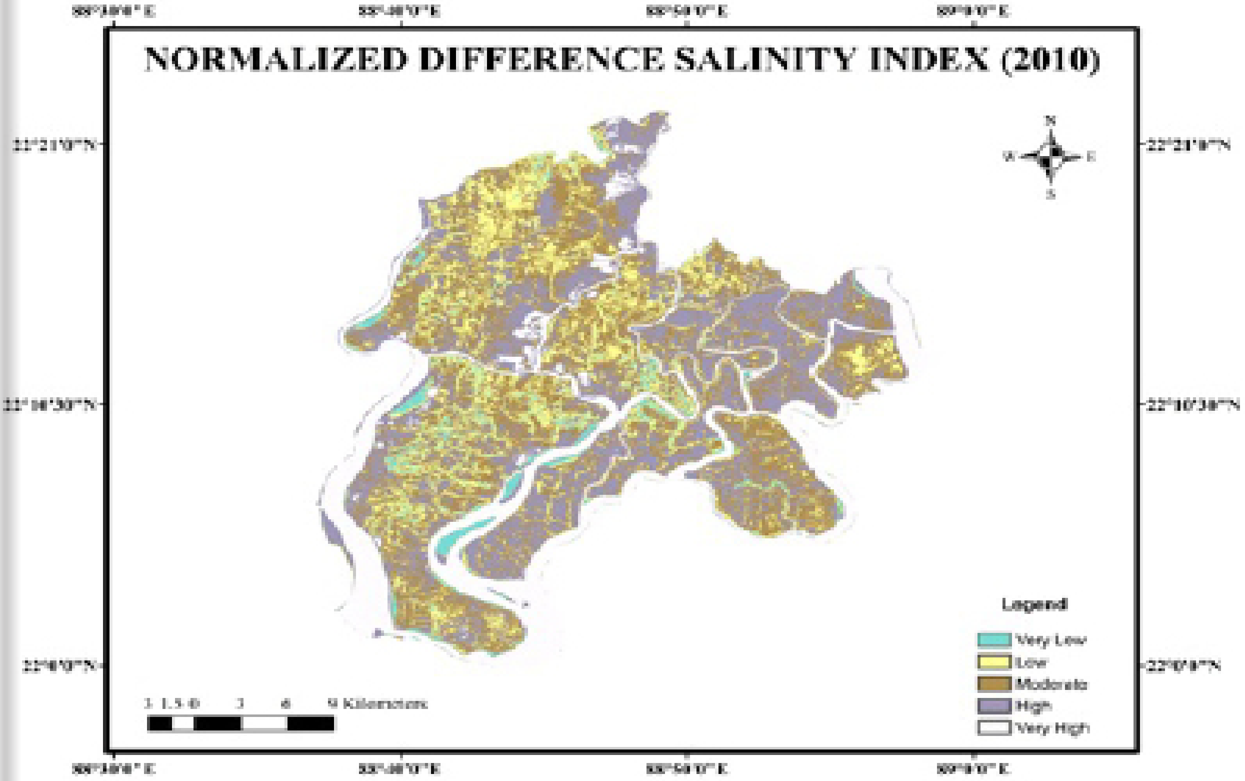


Fig.4.15 NDSI 2010

Correlation Between NDSI AND SAVI from 1975-2010

The correlation between the SAVI and NDSI of the 1975(Fig.4.16) showed the negative relationship through the trend line by joining the data points.Since The SAVI (Vegetation condition) is dependant over NDSI(salinity condition),the NDSI was considered in the X axis and SAVI on Y axis.The same negativity in relationship of two indices were more pronounced in the 2000 (Fig.4.17) and 2010 (Fig.4.18) images. Overall the correlation was derived to generate inverse relationship between vegetation health with the salinity condition over study area. Wherever the vegetation health detoriated the salinity got increased and in the places of healthy vegetation condition the impact of salinity was less. These scenario was analysed through the generation of indices.

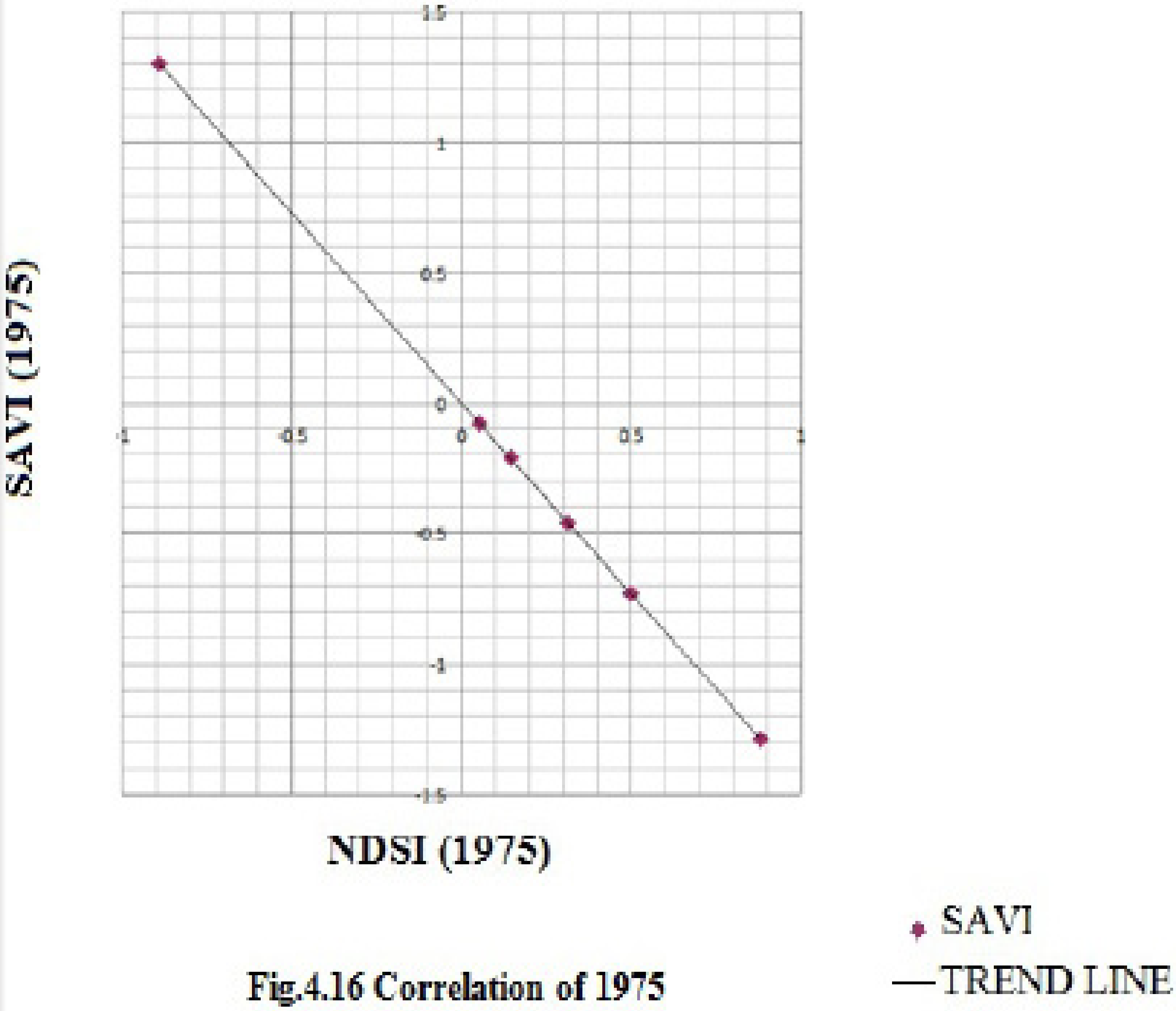


Fig.4.16 Correlation of 1975

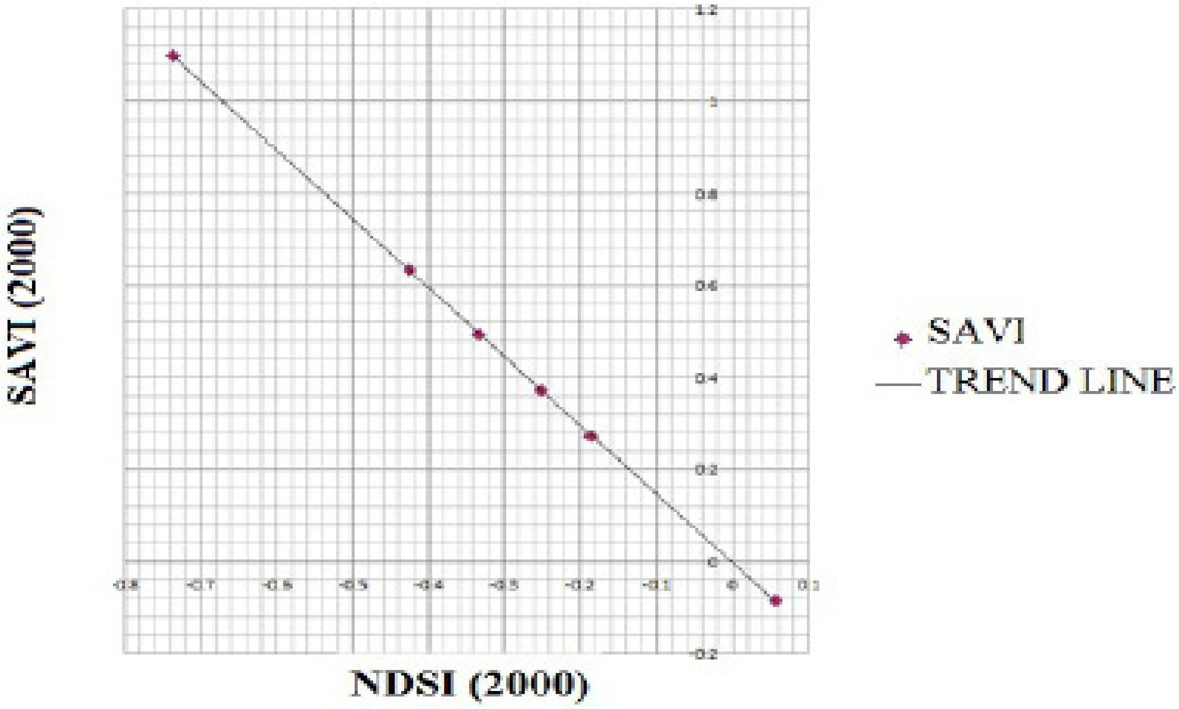


Fig.4.17 Correlation of 2000

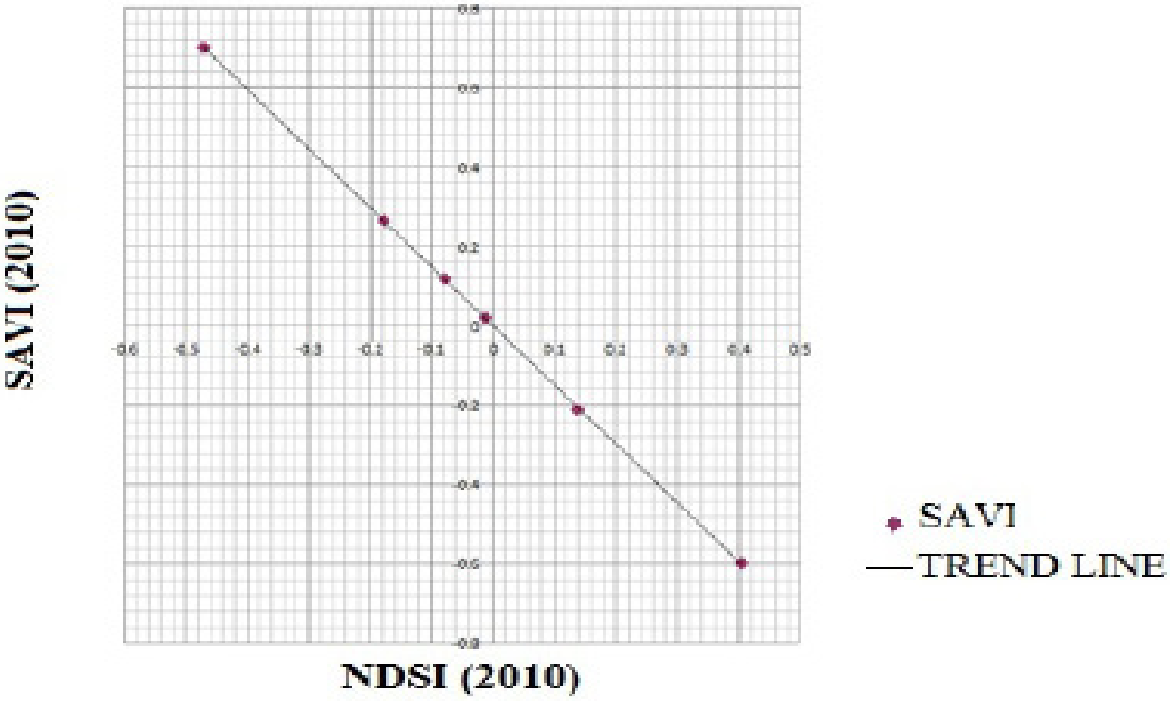


Fig.4.18 Correlation of 2010

Waterlogged Condition Analysis

Considering the slope and the land surface, excess amount of water accumulation salinity might be caused due to waterlogging over an area.The SRTM data 2010 with 90m resolution were analysed in virtual GIS on the basis of elevation variation over the entire study area.The highest elevation was 21m.From the analysis of data (Fig.4.19) it was visible the north eastern part near punjal ,kumaramari,Rangabalia are the most affected part by the water. So it might be assumed that due impact of cyclone in the year 1999 the water got accumulated in the lower elevated areas and responsible for over salinization over those areas.

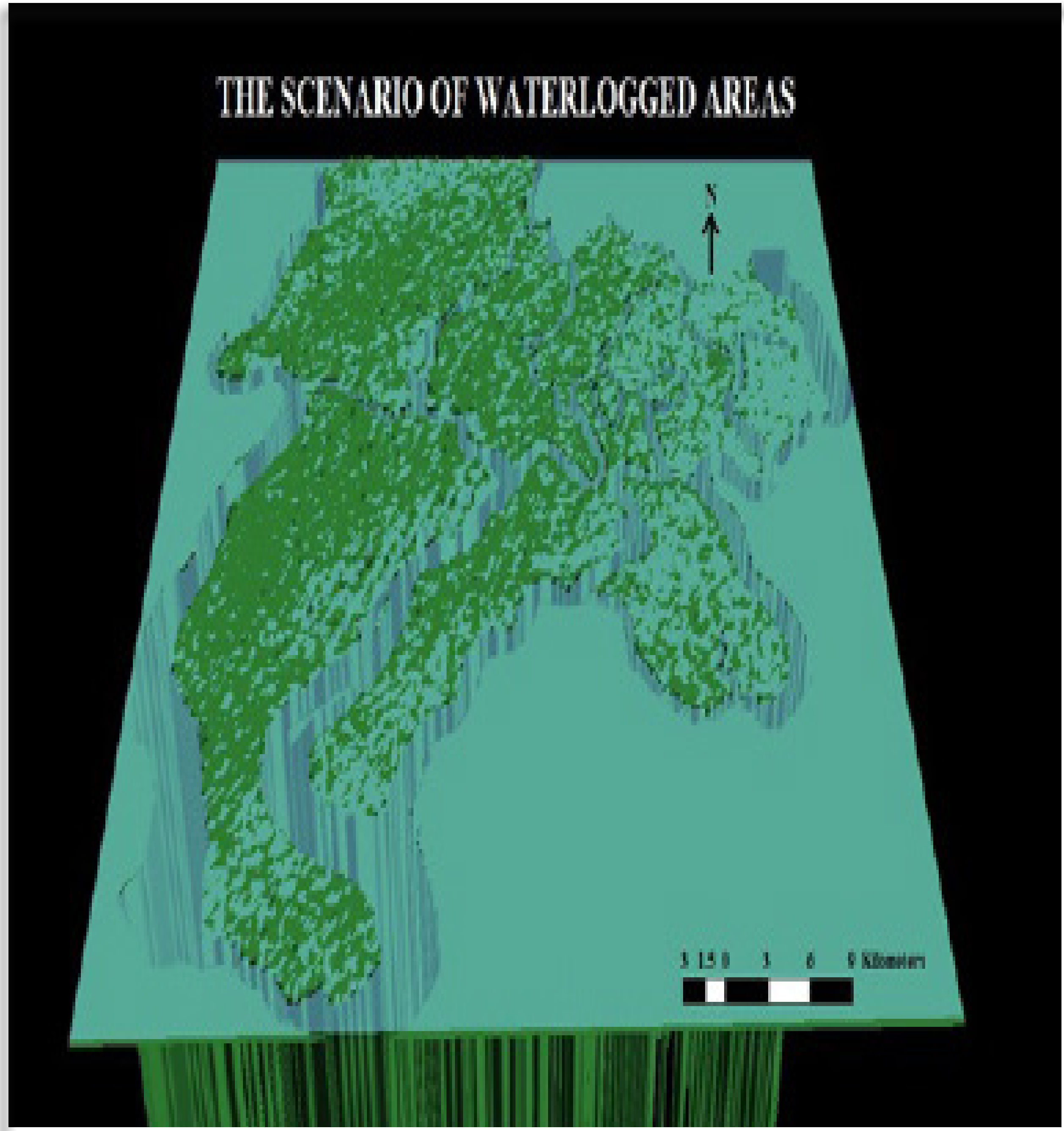
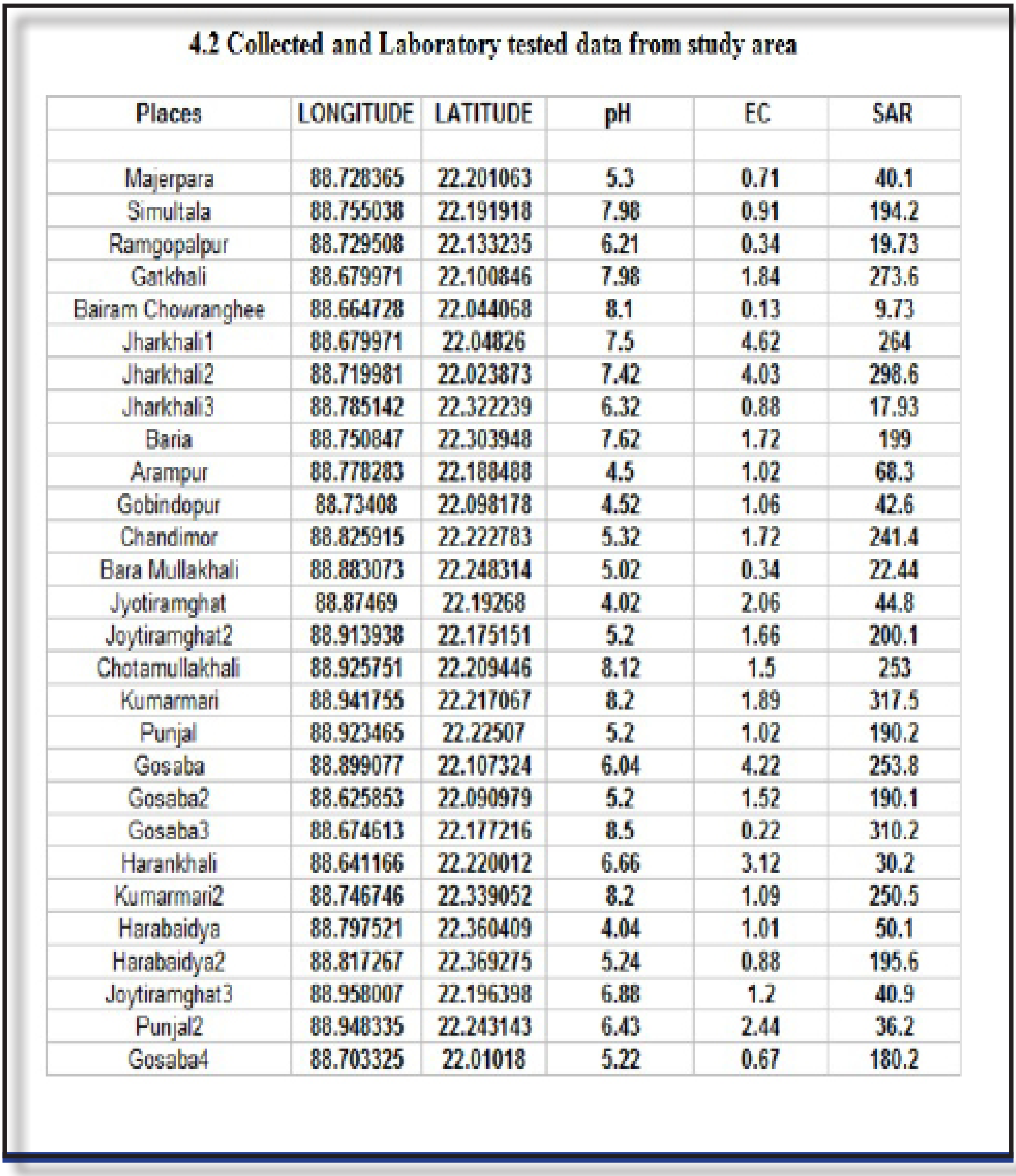


Fig.4.19 Waterlogged Condition of study area

Validation of Work from Field Data collection

Field data for validating the remote sensing based indices analysis from the perspective of salinity were collected. The soil samples along with the GPS(Global Positioning System) positions (Longitude, Latitude) were collected and tested in laboratory method to derive the parameters like Ph, Electrical Conductivity(ds/m) and sodium absorption ratio to check the salinity status of the study area. According to Indian Standard Of Salinity (pH <8.5, EC>4,SAR<13(saline soil) and >13(Alkaline soil).



4.2 Collected and Laboratory tested data from study area

Places	LONGITUDE	LATITUDE	pH	EC	SAR
Majerpara	88.728365	22.201063	5.3	0.71	40.1
Simultala	88.755038	22.191918	7.98	0.91	194.2
Ramgopalpur	88.729508	22.133235	6.21	0.34	19.73
Gatkhali	88.679971	22.100846	7.98	1.84	273.6
Bairam Chowranghee	88.664728	22.044068	8.1	0.13	9.73
Jharkhali1	88.679971	22.04826	7.5	4.62	264
Jharkhali2	88.719981	22.023873	7.42	4.03	298.6
Jharkhali3	88.785142	22.322239	6.32	0.88	17.93
Baria	88.750847	22.303948	7.62	1.72	199
Arampur	88.778283	22.188488	4.5	1.02	68.3
Gobindopur	88.73408	22.098178	4.52	1.06	42.6
Chandimor	88.825915	22.222783	5.32	1.72	241.4
Bara Mullakhali	88.883073	22.248314	5.02	0.34	22.44
Jyotiramghat	88.87469	22.19268	4.02	2.06	44.8
Joytiramghat2	88.913938	22.175151	5.2	1.66	200.1
Chotamullakhali	88.925751	22.209446	8.12	1.5	253
Kumarmari	88.941755	22.217067	8.2	1.89	317.5
Punjal	88.923465	22.22507	5.2	1.02	190.2
Gosaba	88.899077	22.107324	6.04	4.22	253.8
Gosaba2	88.625853	22.090979	5.2	1.52	190.1
Gosaba3	88.674613	22.177216	8.5	0.22	310.2
Harankhali	88.641166	22.220012	6.66	3.12	30.2
Kumarmari2	88.746746	22.339052	8.2	1.09	250.5
Harabaidya	88.797521	22.360409	4.04	1.01	50.1
Harabaidya2	88.817267	22.369275	5.24	0.88	195.6
Joytiramghat3	88.958007	22.196398	6.88	1.2	40.9
Punjal2	88.948335	22.243143	6.43	2.44	36.2
Gosaba4	88.703325	22.01018	5.22	0.67	180.2

Salinity Status Checking according to pH Condition

According to the derived pH values all over the study area the zonation (Fig.4.20) has been carried out to check the distribution of values on the basis of very high, high, moderate, low, very low zones of pH. Gosaba, Rangabelia, Gobindapur, Bhanga Abad, Gholpara areas are the indicator of very high and higher zones and the pH values ranges between 4-5.The moderate values occupied near Sibpur, Baramurakhali, Simultala between 5-6. The low and very low value areas were Kalhabazar, Majerpara, Dhola, Amrata, Bhangankhali, Taldah from 7 to >8.

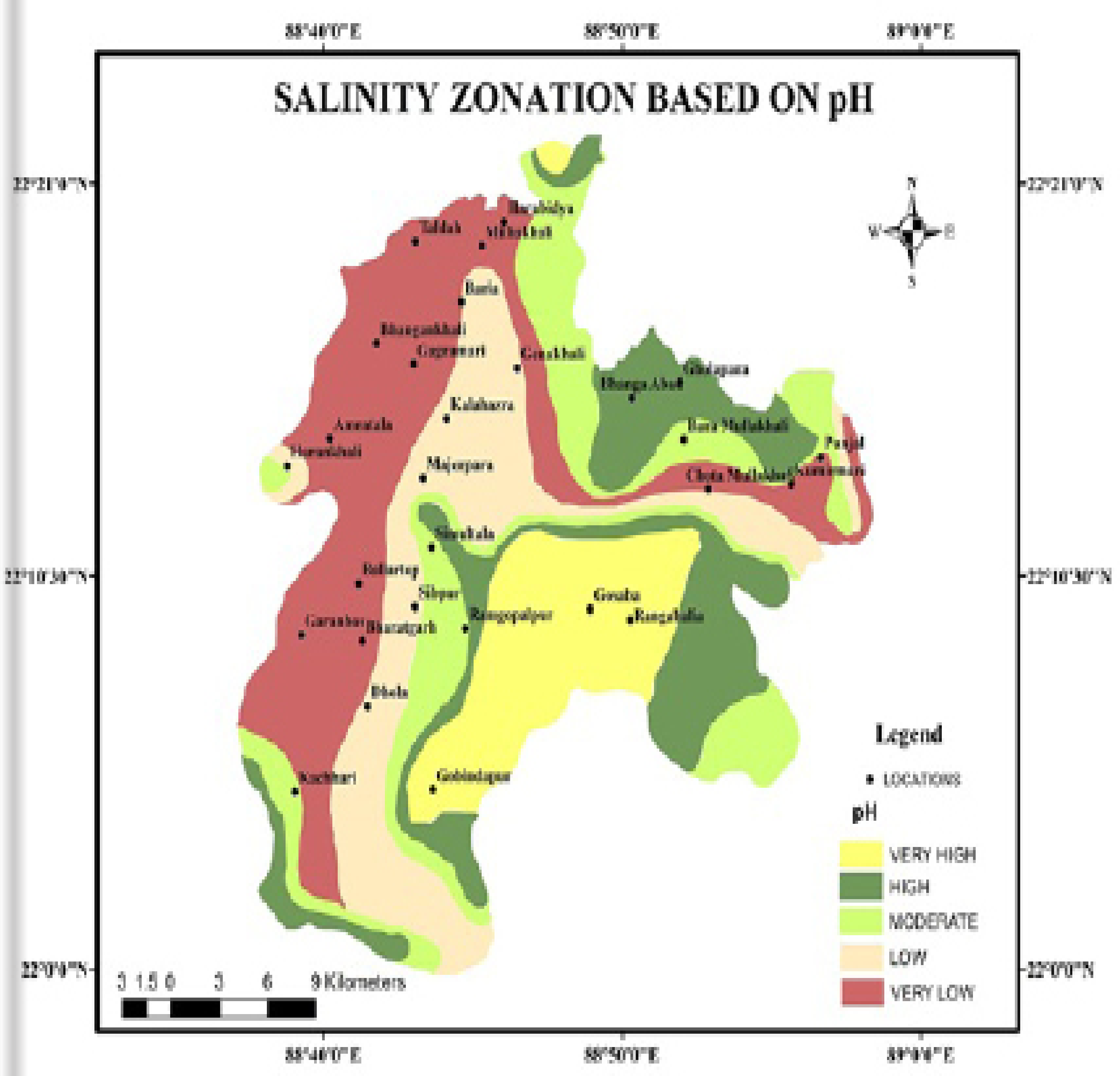


Fig.4.20 The Salinity Status according to pH Values

Salinity Status Checking According to Electrical Conductivity(ds/m)

Electrical Conductivity is one of those measures of salinity which was used to check the salinity status of the study area. Accoeding to the laboratory tested values the zonation of EC (Fig.4.21) were done through ArcGIS 9.3 software.The very highand high accumulation of EC values were found near Gobindapur,Rangabelia,Gosaba,Moderate zones were under Bhangankhali,Amratala,Taldah areas. Otherwise very low and low values were found near Kachari,Simultala,Baramurakhali,Chotamurakhali,Harabidya.The EC values (Table.4.2) were deviated to some extent from the usual Indian Standardized values of EC.

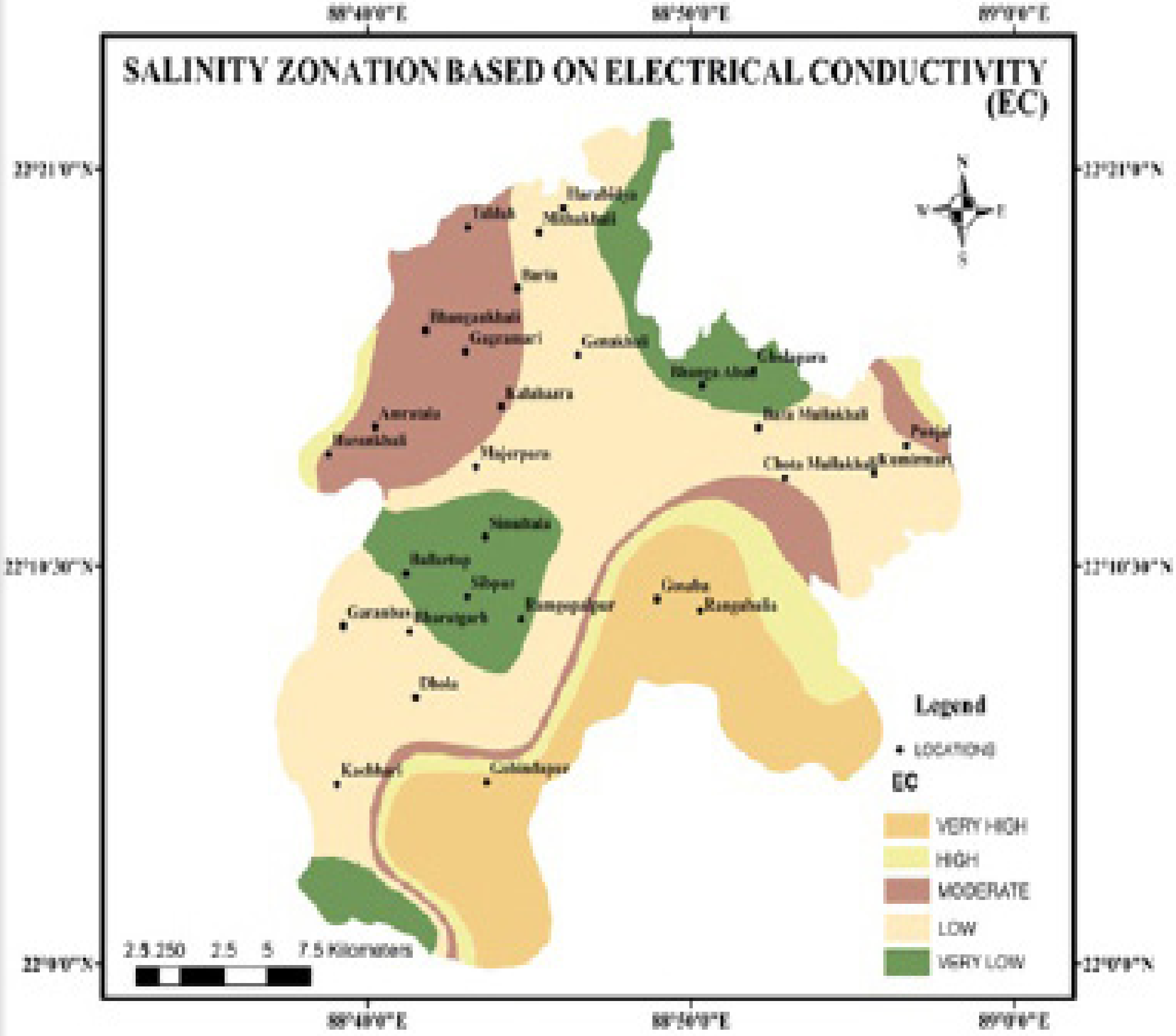


Fig.4.21 The Salinity Status according to EC (ds/m) values

Correlation Between pH and NDSI

Correlation (Fig.4.22) between pH and NDSI were derived to check the salinity condition over the study area. It shows the negative relation through straight line equation and trend line. The root mean square value shows approximation of data points as well as the normal R2 value(between 0-1).It does not show any deviation from normal values. Wherever NDSI value is high (+1) the pH value is low (<8.2).It indicates the high salinity and the two variables are well correlated. It predicted the salinity with high accuracy like remote sensing analysis.

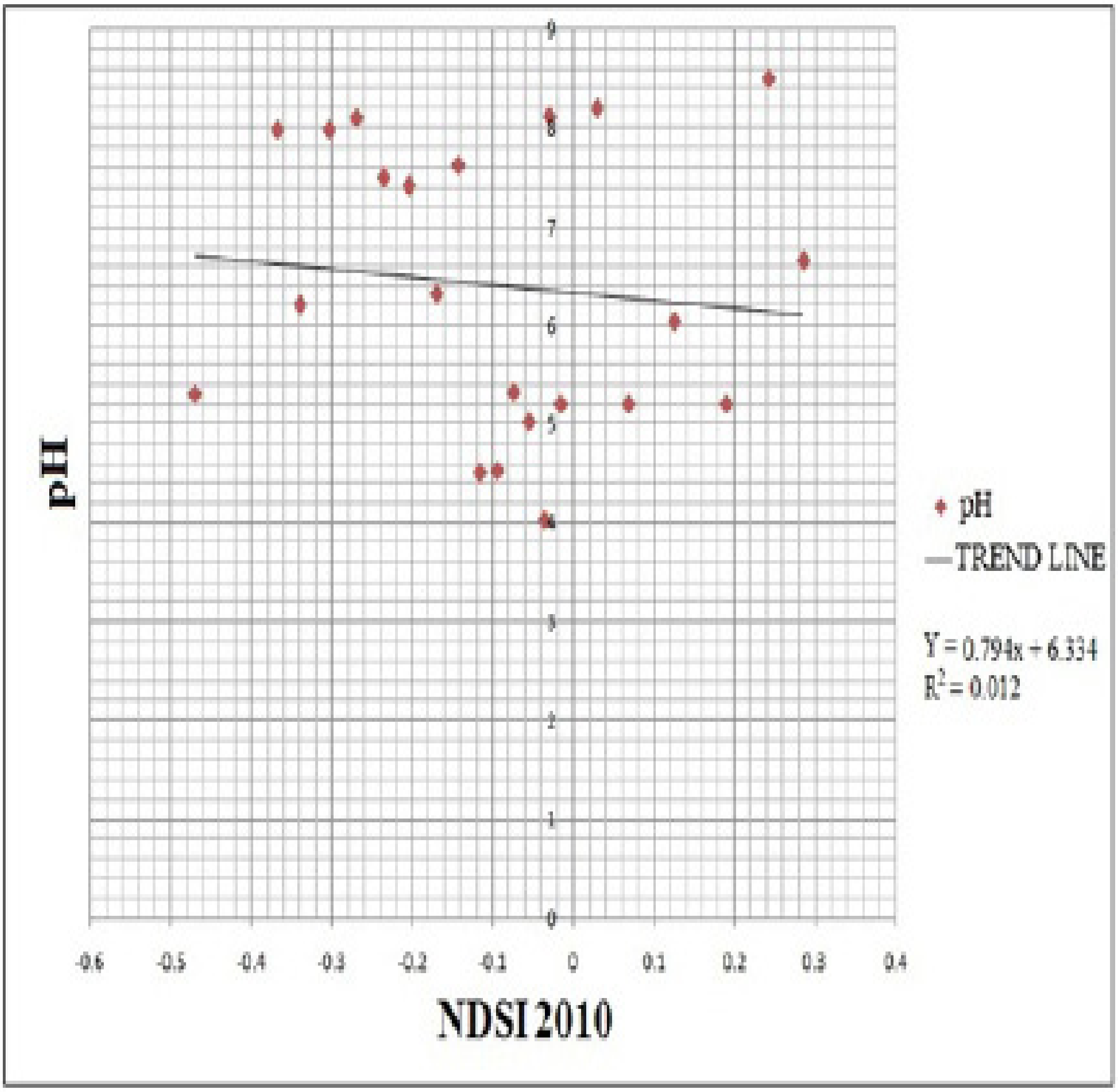


Fig.4.22 Correlation Between pH and NDSI

Correlation Between EC(ds/m) and NDSI

The correlation (Fig.4.23) between EC(ds/m) and NDSI indicating the positive relation between the above two variables. It indicates wherever NDSI values are high(+1),the EC values are also high. But to some extent this correlation got deviated since EC values for salinity has to be >4 according to Indian Standard and acquired EC values by lab testing showed very few values above 4 and mostly <4.The R_2=0.033 value ranges between 0-1.Therefore it does not match the remote sensing analysis very accurately but almost near to that.

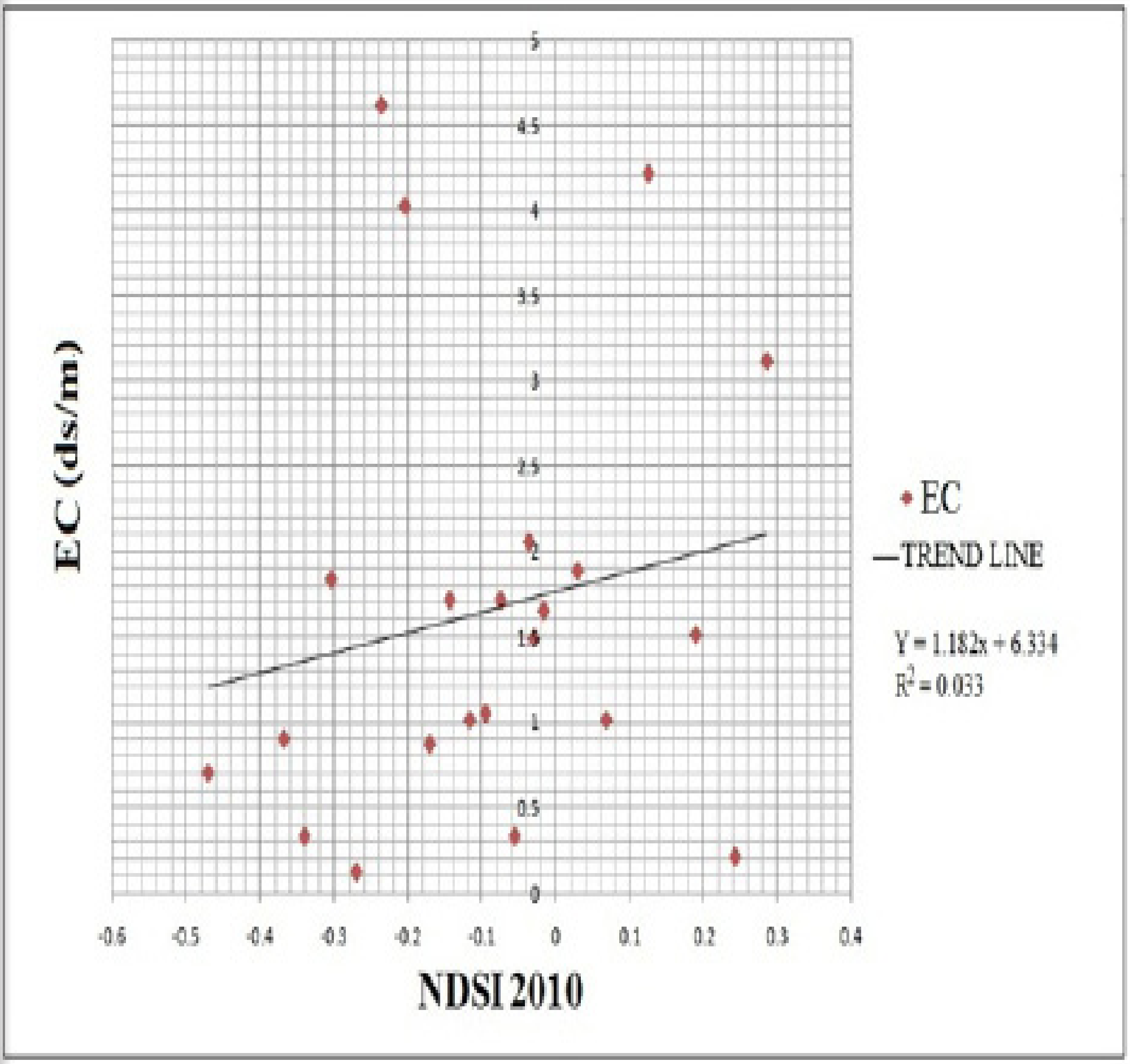


Fig.4.23 Correlation Between EC and NDSI

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Validation of NDSI from Ground data

Since the acquired pH values from soil sample testing showed high accuracy in prediction of salinity. The pH values were overlaid (Fig.4.24) on the NDSI 2010 to check the accuracy of remote sensing method of salinity zone identification through indices based analysis. In result of the validation, it showed high accuracy. Wherever very high and high zones of NDSI (near+1) were found pH values also showed between 4-5 and moderate NDSI matched with moderate pH values between 5-6 and low and very low values for ph ranged from 7 to >8 which matched the low NDSI (-1) values and indicated low saline zones. So it can be concluded that empirical analysis matched with the remote sensing analysis for salinity zone prediction and identification.

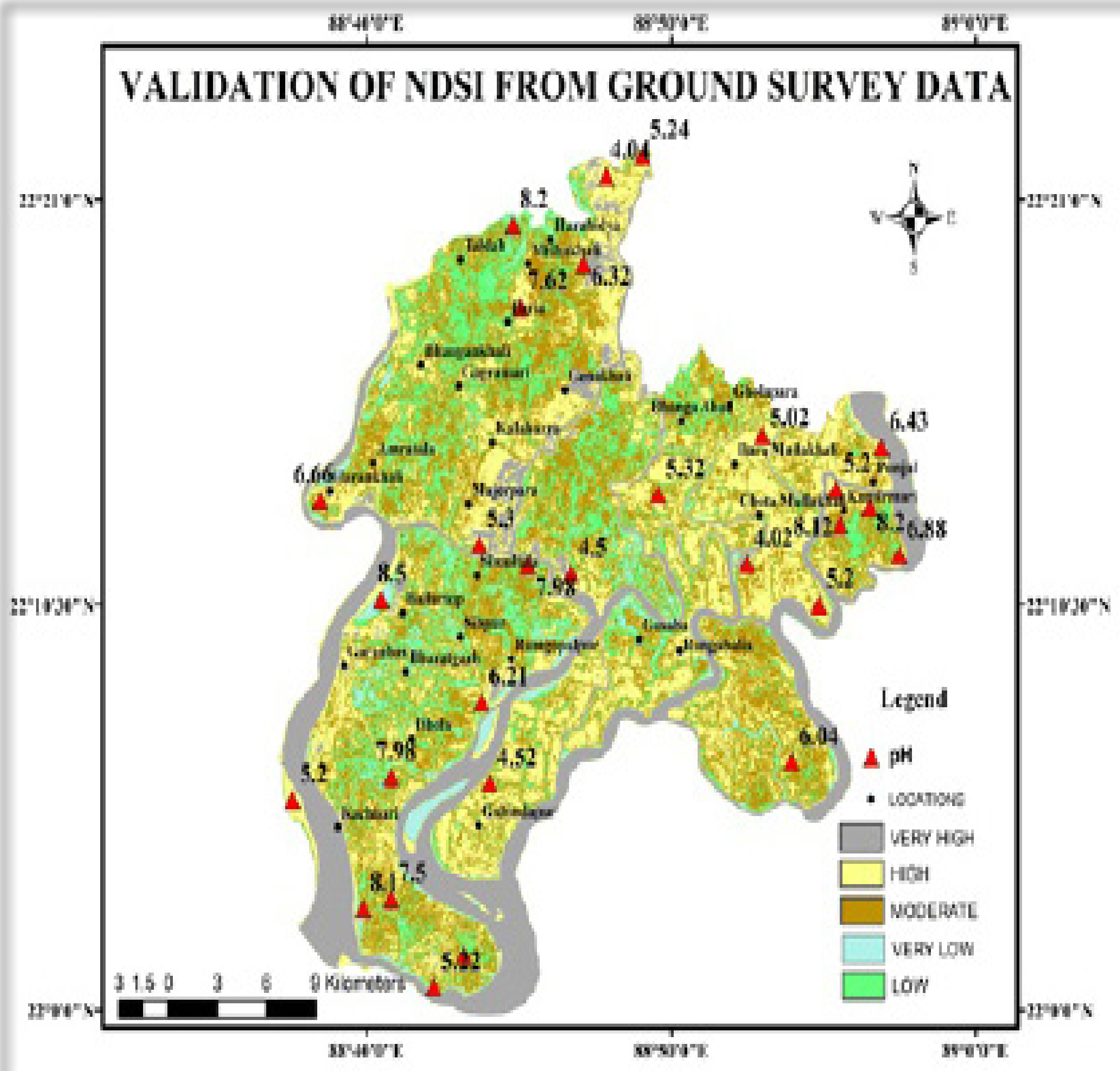


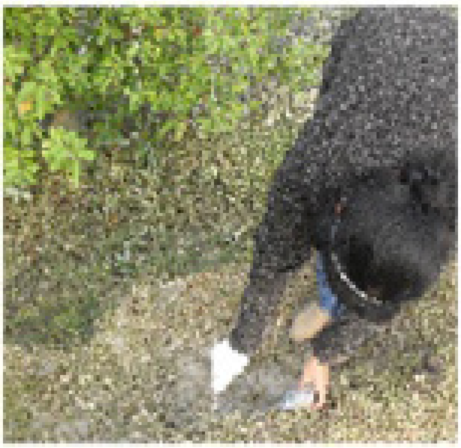
Fig.4.24 Validation of Remote Sensing Analysis from Ground sampling

1.Agricultural Field

2.Riverbank Side

3.Bidya Riverbank

4.Devastated Mangrove by Cyclone Aila(2009)



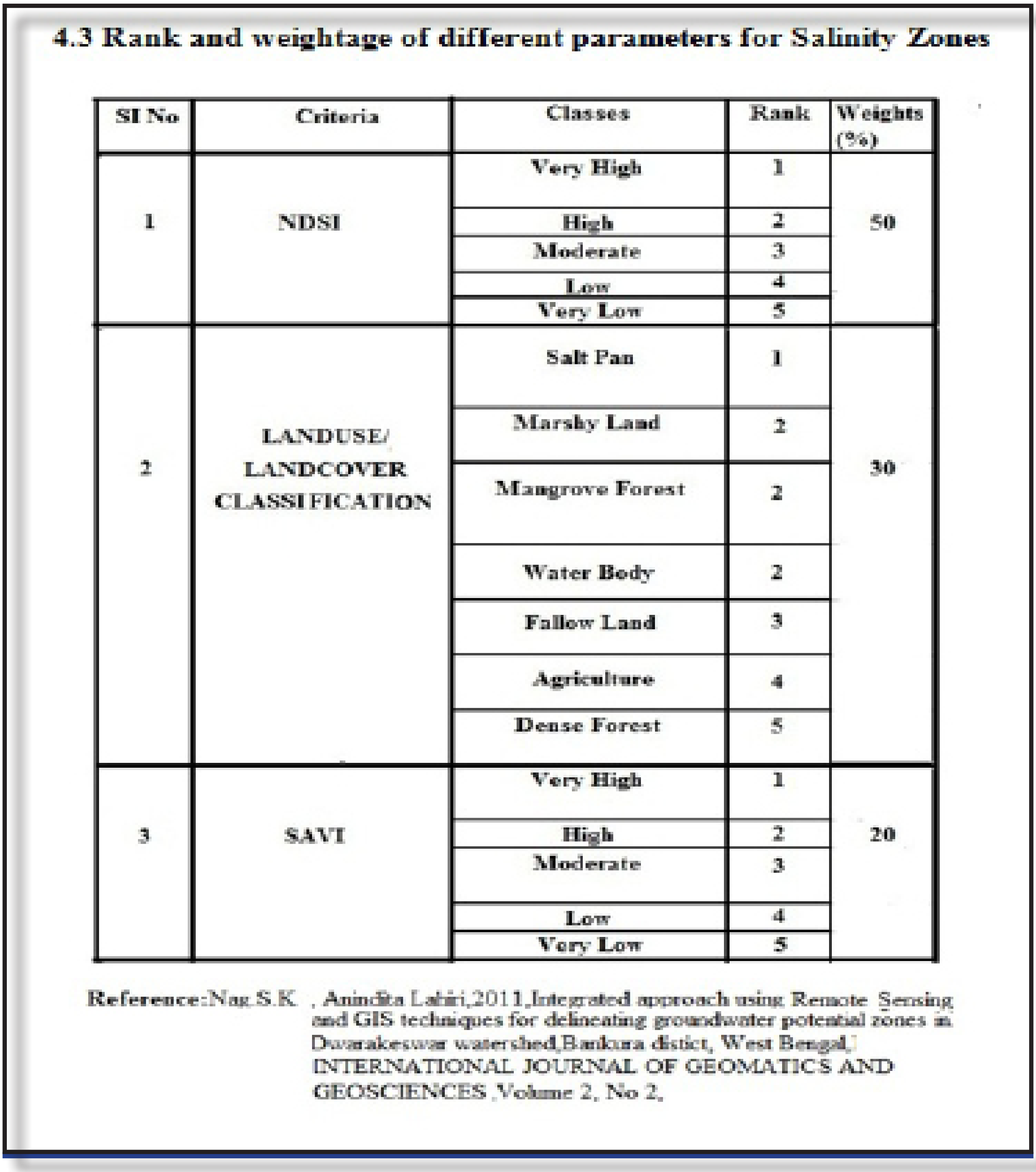
5.Collection of Soil Samples

6.Development Project of Govt.

Fig.4.25 Field Photographs

Weighted Overlay Analysis from 1975-2010

The salinity zones were identified and mapped by overlaying all the thematic maps (Landuse/landcover map,SAVI,NDSI) which were considered as an important parameters from perspective of salinity by weighted overlay methods using the spatial analysis tool in ArcGIS 9.2. During the weighted overlay analysis, The ranking has been given for each individual parameter of each thematic map and the weights were assigned according to the influence of the different parameters, showing in Table 4.3. The analysis carried out for the year 1975, 2000, 2010.



4.3 Rank and weightage of different parameters for Salinity Zones

SI No	Criteria	Classes	Rank	Weights (%)
1	NDSI	Very High	1	50
		High	2	
		Moderate	3	
		Low	4	
		Very Low	5	
2	LANDUSE/ LANDCOVER CLASSIFICATION	Salt Pan	1	30
		Marshy Land	2	
		Mangrove Forest	2	
		Water Body	2	
		Fallow Land	3	
		Agriculture	4	
		Dense Forest	5	
3	SAVI	Very High	1	20
		High	2	
		Moderate	3	
		Low	4	
		Very Low	5	

Reference:Nag S.K , Anindita Lahiri,2011,Integrated approach using Remote Sensing and GIS techniques for delineating groundwater potential zones in Dwarakeswar watershed,Bankura distict, West Bengal, INTERNATIONAL JOURNAL OF GEOMATICS AND GEOSCIENCES ,Volume 2, No 2,

Salinity Zone Identification of 1975,200,2010

NDSI, SAVI, Landuse/Landcover maps of 1975,2000,2010 were converted into grid (raster format) and superimposed by weighted overlay method (rank and weightage wise thematic maps). From the analysis of 1975(Fig.4.26) salinity zones in-terms of High, Moderate and Low zones with the areas of 84.56 Km^2, 423.69Km^2,300.79Km^2 were acquired respectively.The similar procedure was followed to derive salinity zones of the year 2000(Fig.4.27) and 2010(Fig.4.28). In the year 2000 the identified areas for High, Moderate, Low salinity were 134Km^2,163Km^2 and 512Km^2 respectively. Whereas in 2010 amount of High saline land became 233.46Km^2,Moderate 322.20Km^2 and Low was 252.95Km^2.The fluctuation in area (sq.km) are shown in the Fig.4.29.

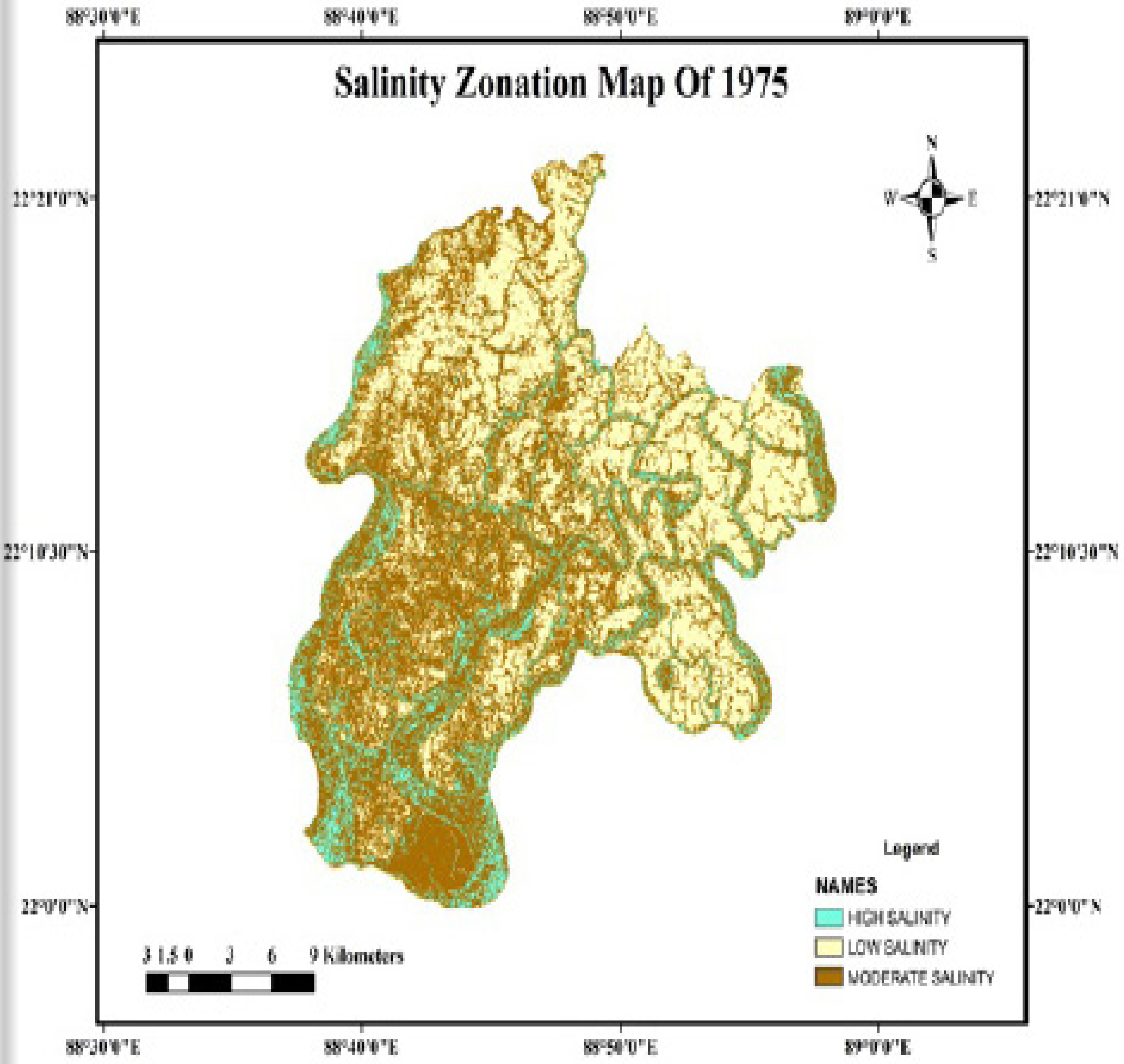


Fig.4.26 Salinity Zonation of 1975

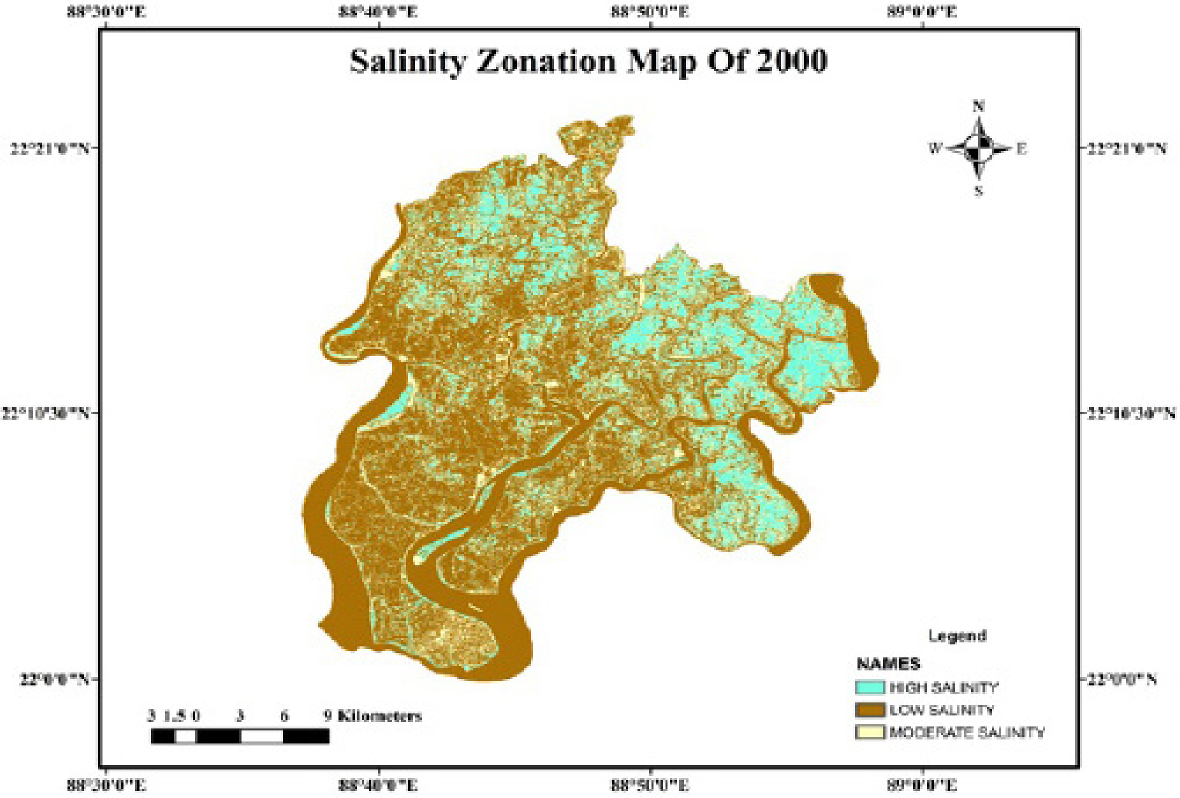


Fig.4.27 Salinity Zonation of 200

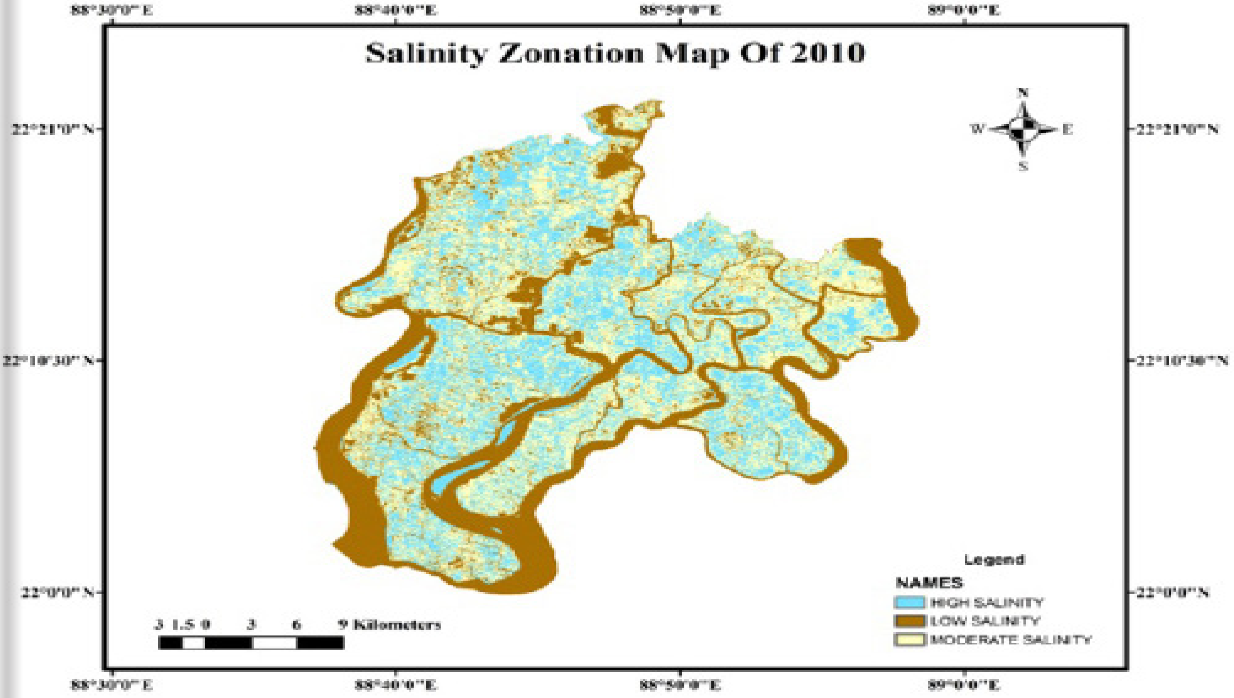


Fig.4.28 Salinity Zonation of 2010

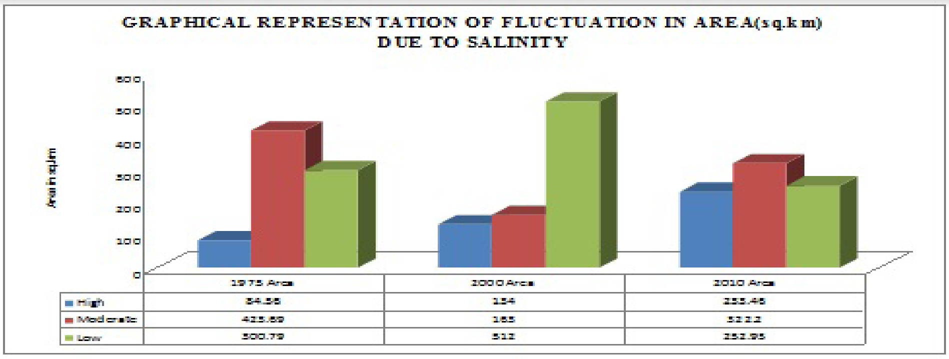
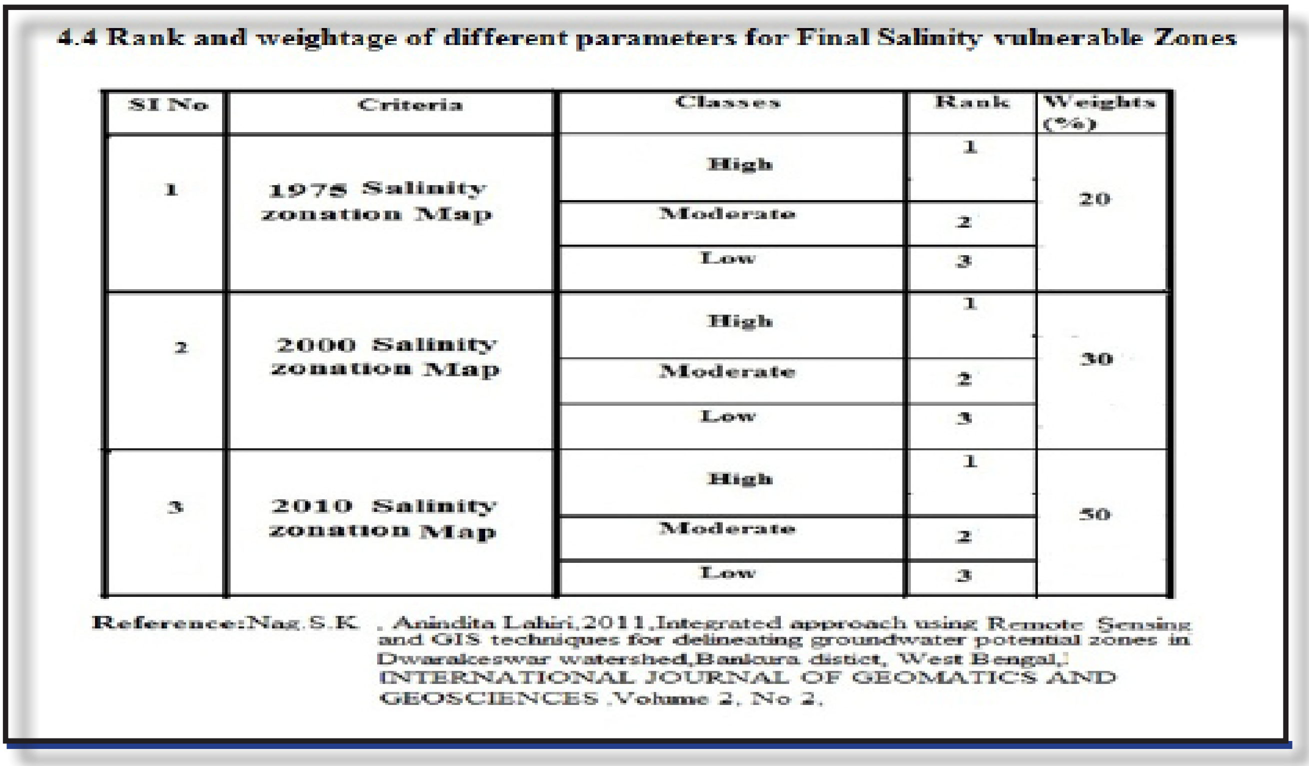


Fig.4.29 Graphical Scenario of area(km^2) Changes due to Effect of Salinity

4.1.18 Salinity Vulnerability Index Map

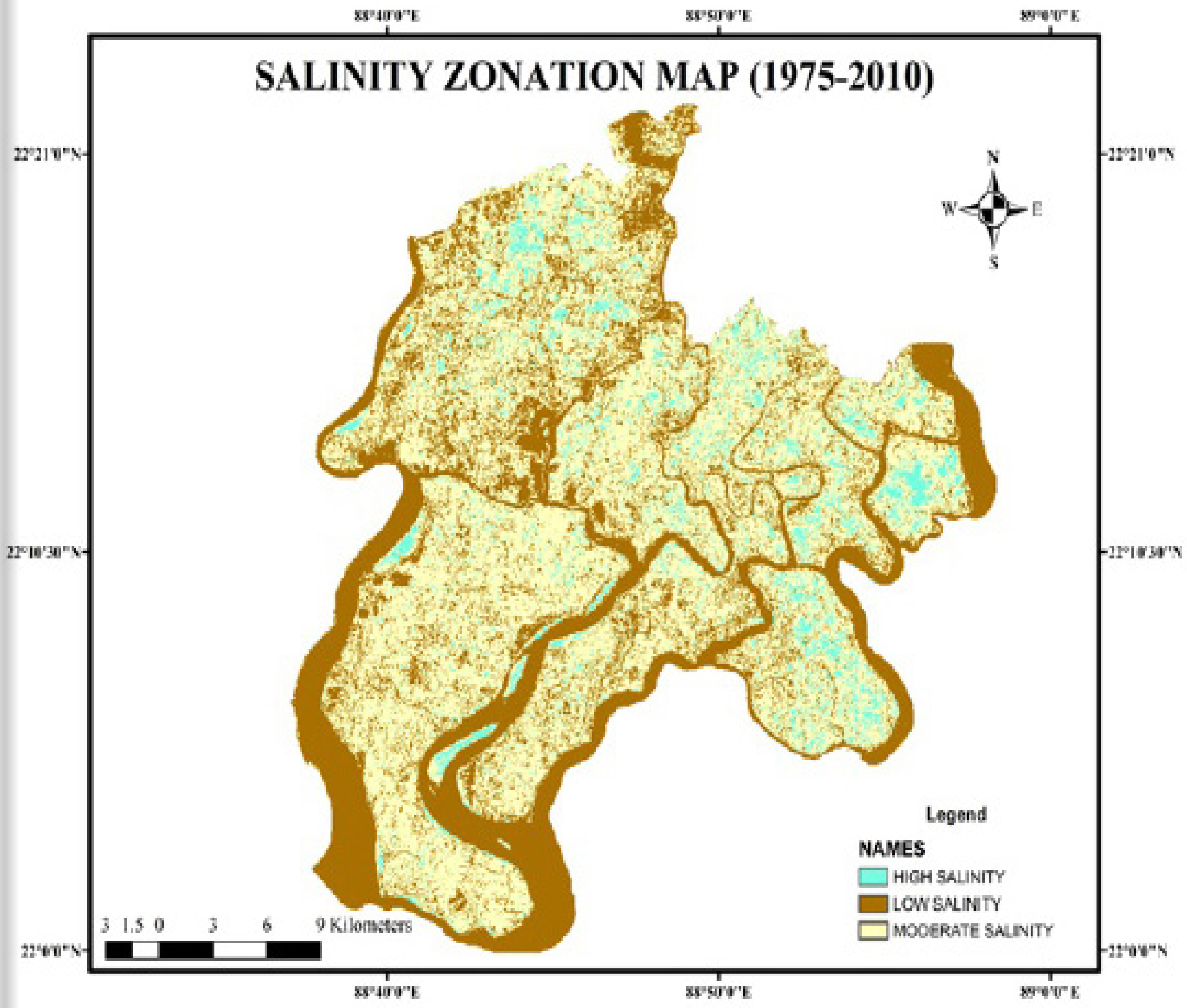
Final salinity vulnerability index map was prepared by overlaying the output from weighted ovelay analysis of 1975,2000,2010. During the weighted overlay analysis,the ranking has been given for each individual parameter of each thematic map and the weightage were assigned according to the influence of the different parameters.The areas of high saline land got increased in 2010 than 2000 and in 2000 salinity areas increased than 1975.Thus higher weightage was given to 2010 (50%),2000(30%),1975(20%) showing in Table 4.4.On this basis the final salinity zones were identified and mapped (Fig.4.29) showing high saline zones in north eastern part along with the mangrove patches,majority of land were occupied by moderate amount of salinity and low saline areas were visible in the waterbodies.It is assumed due to devastating cyclonic effect by Aila in 2009 the immense changes has taken place over the two islands Gosaba,Basanti and amount of saline land surface has increased from 1975-2010.



4.4 Rank and weightage of different parameters for Final Salinity vulnerable Zones

Sl No	Criteria	Classes	Rank	Weights (%)
1	1975 Salinity zonation Map	High	1	20
		Moderate	2	
		Low	3	
2	2000 Salinity zonation Map	High	1	30
		Moderate	2	
		Low	3	
3	2010 Salinity zonation Map	High	1	50
		Moderate	2	
		Low	3	

Reference:Nag.S.K , Anindita Lahiri,2011,Integrated approach using Remote Sensing and GIS techniques for delineating groundwater potential zones in Dwarakeswar watershed,Bankura distict, West Bengal,' INTERNATIONAL JOURNAL OF GEOMATICS AND GEOSCIENCES ,Volume 2, No 2,



4.30 Salinity Vulnerability Index Map

CONCLUSION

The work carried out in the project is the data collection for salinity zone identification over the study area along with that the preparation of objective and methodology to reach conclusion by using Optimal GIS and Remote Sensing Method. Thus in major finding Salinity zonation Map was prepared along with that indices based and ground truth collection through an integrated approach to analyse the spatio - temporal scenario over the study area due to dynamic activities by sea and wind over the Gosaba and Basnati Island.classification were adopted to separate landuse/landcover classes and to view the area conversion because of salinization from the year 1975 to 2010. The Salinity zones have been derived for the entire study area and it has been divided high, moderate and low zones.

RECOMMENDATION

The study area Gosaba and Basanti island are prone to cyclonic activities as well as the constant changes due to together contribution of sea water and wind. The soil salinity depends on these dynamic act. Due to over increase of saline condition the vegetation, crop as well as the micro organism might be affected which in tern might cause an adverse effect on environment. Thus measures should be taken by initiative of Govt. and local people to protect crop, maintain soil properties and vegetation health.Recently Mangrove Protection, Building of Embankment, Polderization, building of drainage system along the agricultural field to supply water, avoiding of over fertilization, maintenance of water level in the crop land etc are being adopted to protect the major two islands of Sunderban for prosperity and future development and for reducing the effect of salinity over the land.

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